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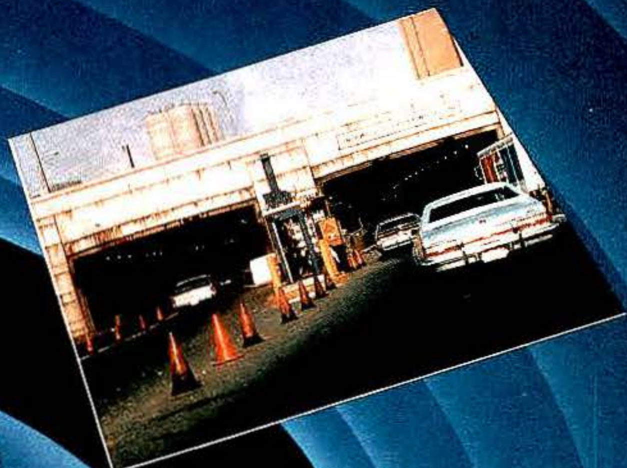
Mobile Radio Technology

The journal of mobile communications technology



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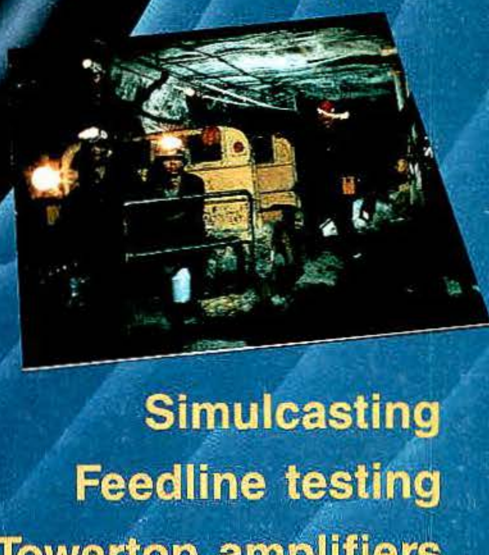

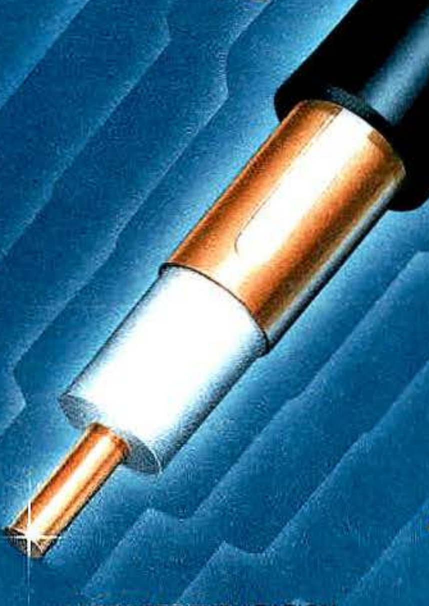

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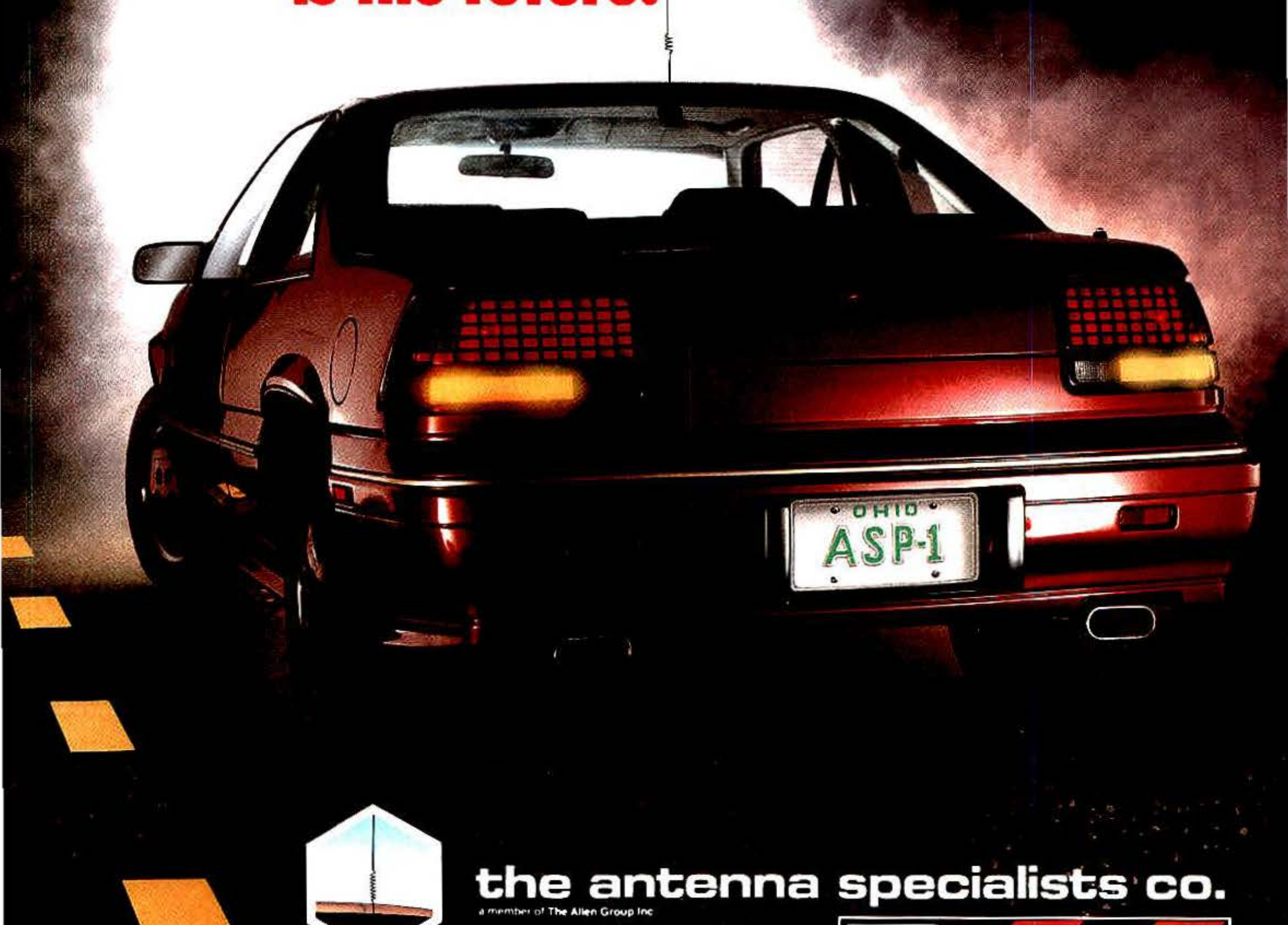

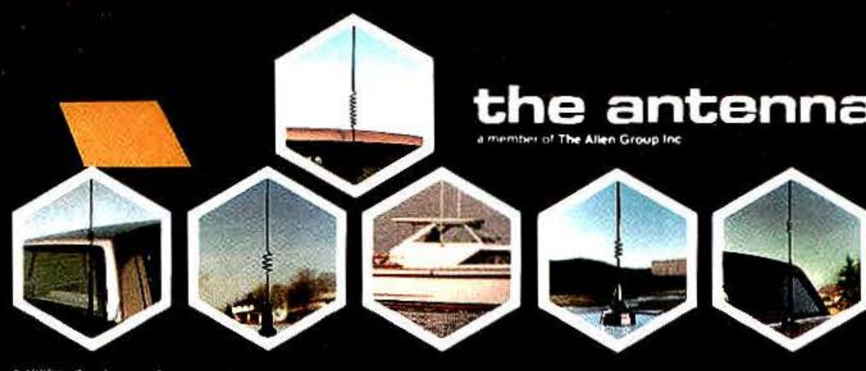

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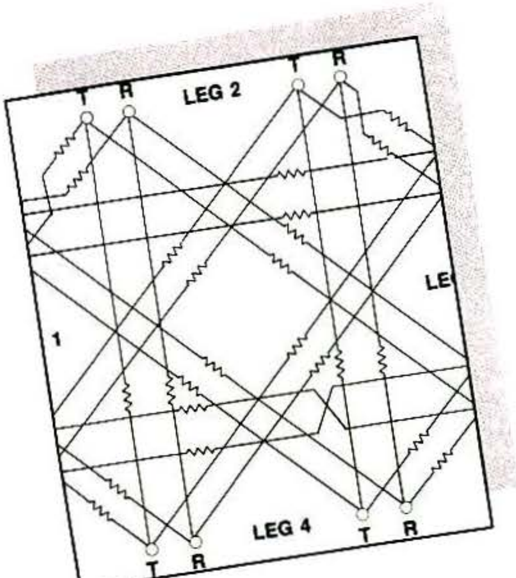

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features

On the cover: Coaxial cable extends radio communications where antennas cannot go. See article on page 10. Artwork courtesy of Cablewave Systems.

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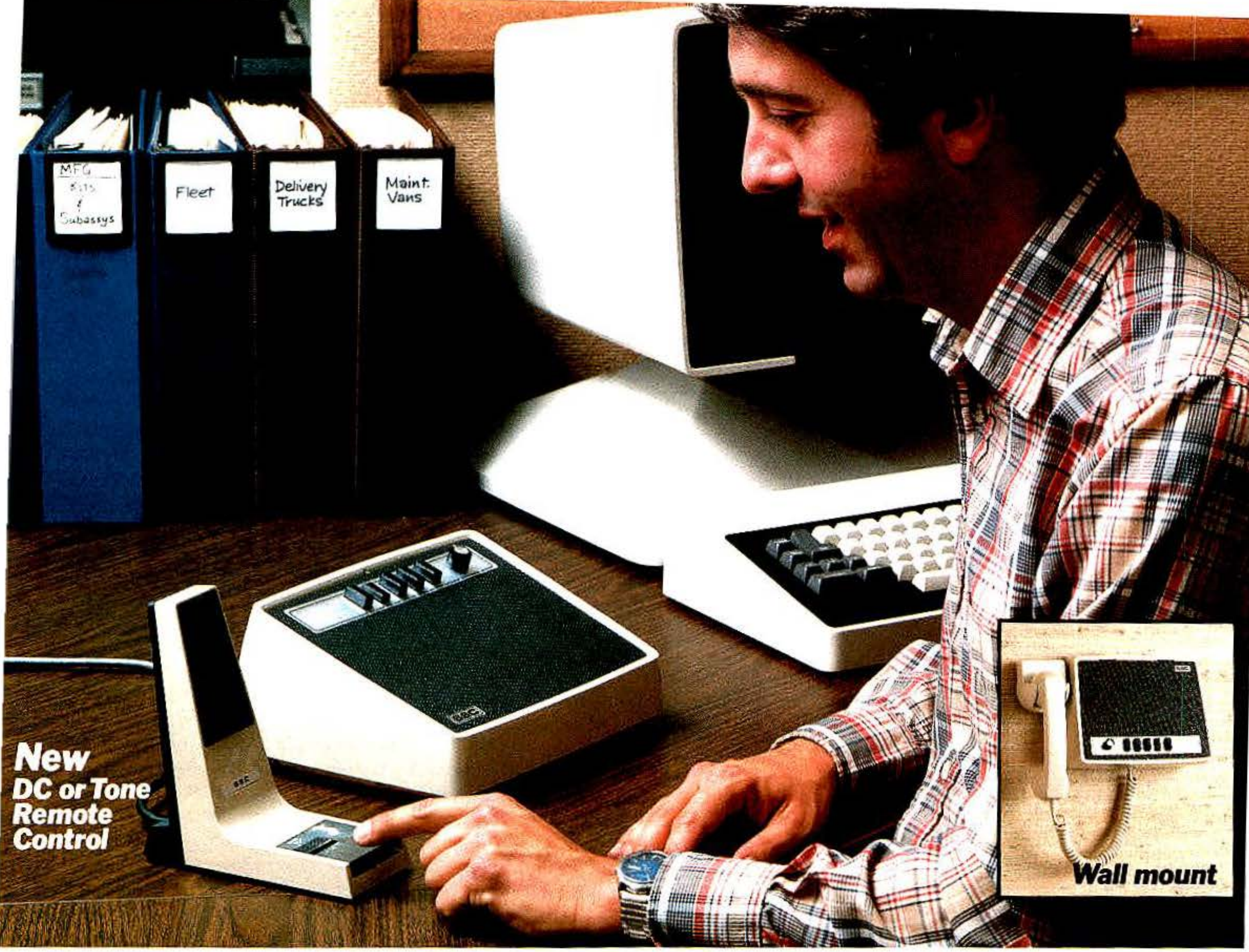
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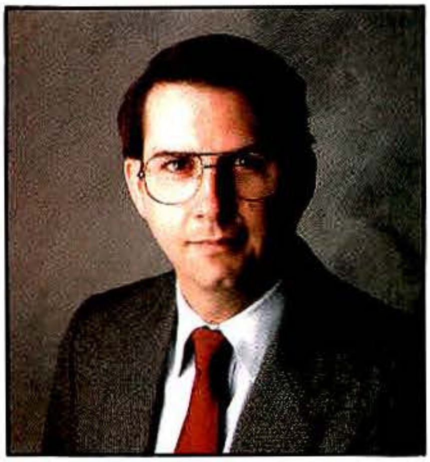
Editorial

Telocator votes down private carrier membership



Telocator members may be doomed forever to struggle with the question of whom to grant membership and whom to bar.

For many years, the paging and mobile telephone association barred wireline companies from its roster.

Then the industry changed:

(1) Many of Telocator's non-wireline members were gobbled up by wireline companies. The association's membership roster suffered as the converted wireline members were forced to withdraw.

(2) As cellular telephone systems were activated, wireline companies enjoyed a headstart. But they could not join Telocator. Instead, they joined the Cellular Telecommunications Industry Association (CTIA). Following their lead, many non-wireline companies joined CTIA as they activated their systems.

Eventually, the remaining Telocator members opened the association's doors to wireline membership. Understandably, wireline companies' reactions, at least on the cellular side, have been lukewarm. Telocator has made some gains on the paging side.

Play it again

In what may become a replay of the wireline membership experience, Telocator members voted to bar private carrier paging (PCP) system operators and specialized mobile radio (SMR) system operators from membership.

Meanwhile, PCP system operators are welcome at the National Association of Business and Educational Radio (NABER), which has formed as a membership section the Association for Private Carrier Paging (APCP). SMR system operators are welcome at NABER and the American SMR Network Association.

If and when Telocator's members change their minds on this aspect of the membership issue, will it be too late?

Telocator wants to be known as "the mobile communications industry association." No. Not yet. Telocator's door isn't open wide enough to let the mobile communications industry through.

People go where they are welcome, and they remember where they have been rebuffed.

* * *

Spectrum speculation

Perhaps the biggest example of spectrum speculation involves applications for cellular mobile telephone system licenses.

Speculators have found another, though by far smaller, slice of spectrum to carve: specialized mobile radio (SMR) channels reserved for conventional, single-channel systems.

Conventional SMR channels remain vacant in some areas where trunked channels all have been assigned. That has led some trunked system operators to apply for the unused conventional channels and to apply for waivers of FCC rules to allow the conventional channels to be trunked along with their existing assignments.

The FCC granted several of these waivers before proposing a rule change that would make the grants a matter of routine, and alleviate the need for waiver requests. When it proposed the rule change, the commission announced it would not consider any similar waiver requests until the rulemaking proceding concludes.

The effect has been an increase in spectrum speculation. License applications are being filed hurriedly for the remaining conventional channels available in areas with high demand for trunked systems. In many cases, the applicants apparently hope only to sell their channel assignments to any nearby trunked system operator for the highest bid, not actually to operate single-channel systems.

As a result, the conventional channels all may be assigned by the time the rulemaking proceeding concludes. Trunked system operators may be denied the opportunity to apply for the channels under the proposed new rule by the practical result of the rulemaking proceding, channels in many cases were made available under waiver request.

Speculators 1, system operators 0.

—Don Bishop

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Volume 1, No. 5

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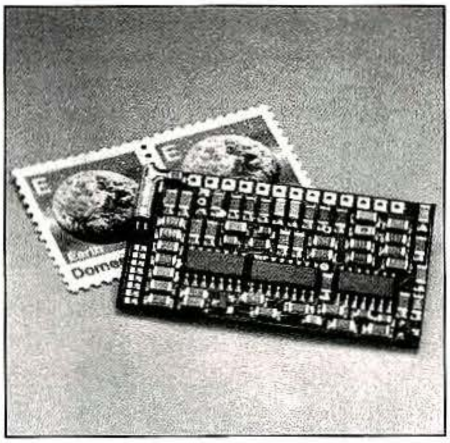

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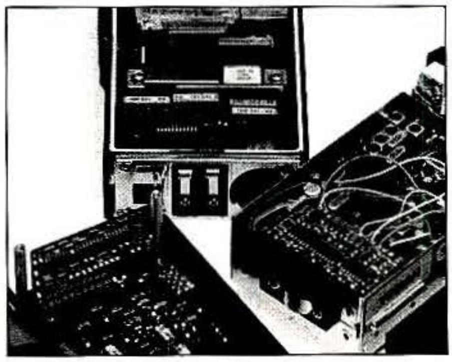

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Letters to the editor

I read with interest and concern two items in *Mobile Radio Technology.*

The first was a letter written by Roy B. Carpenter Jr.; it appeared in this column in July 1988. The second was the article, "Lightning Protection Devices: How Do They Compare?" by Dr. Mark M. Drabkin and Roy B. Carpenter Jr., an article that appeared in the October 1988 issue.

Regarding the letter, the writer's claim of trademark rights to the term, "Dissipation Array" system is invalid because the term is descriptive of the static dissipation array.

It is a gutsy marketing ploy to attempt to trademark and claim for one's own exclusive use a generic industry term. Although I am sure Mr. Carpenter dearly would want the term to apply only to his products, such is not the reality of the situation. It would deprive the other manufacturers the right to describe their own products in industry-recognized terminology objectively.

Mr. Carpenter's attempt is wishful thinking. It would be comparable to a manufacturer of a "diet soft drink" attempting to trademark the term because it was of the opinion that its product was the only "true" diet soft drink on the market and, therefore, the only one that should be referred to by the term. Obviously, the other manufacturers of diet soft drinks would find that claim as outrageous as we find Mr. Carpenter's. The claim would not stand for a moment.

Regarding the article, and without addressing its approach, assumptions, logic or conclusions, I would like to clarify one point: The drawing of the dissipator labeled as a Lightning Master dissipator appears to be that of a Verda brush.

Lightning Master dissipators are not mounted in a fixed configuration, as are other dissipators on the market. Rather, they are installed in various ways that enhance the natural dissipation of an object or structure. Therefore, any rendering of a Lightning Master dissipator would necessarily be specific to the structure upon which it is mounted. I fail to see how the authors can illustrate a Lightning Master dissipator without illustrating the structure to which it is mounted.

Information presented by the letter and article is so far off base that it would take another feature article to even begin to address the erroneous claims, approach, assumptions, logic and conclusions. I trust that potential buyers and specifiers of this type of product are diligent enough in their research to reach the same conclusion.

Bruce A. Kaiser
President
Lightning Master
Brooksville, FL

The toughest problems are poor—almost no—assistance from manufacturers and importers on technical details

Mobile Radio Technology
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R.E. Merideth
Ray-d-o-lab
Pinellas Park, FL

The November 1988 issue is one of the best editions of *MRT* yet! Five good articles in a row—wow!

Harold Kinley does it once again, this time with his great article on performance testing for base receivers.

Please, let's have many more articles from this great technical writer. *MRT* should give him a free advertisement for his book to encourage him to write more articles.

Patrick Sheridan
Bryan Cuniffe & Associates
Seattle

Did you just ask about Harold Kinley's book? It is Standard Radio Communications Manual: With Instrumentation and Testing Techniques, *published by Prentice-Hall in 1985.*

—DB

It is difficult to find and hire good, reliable and reasonable technical help. We need more easily interfaceable equipment.

Marvin Clegg
Mobile Communications
of Flagler County
Bunnell, FL

I appreciate you staying on the cutting edge of the rapidly changing industry of two-way radio.

The toughest problems are staying current with technology and getting the most technology for the money when buying new equipment.

Richard T. Smith
Oklahoma Department
of Transportation
Oklahoma City

I like the problem-solving "war stories" with technical details. I have a trunking project right now, so trunking articles are of interest.

The toughest problems to solve are learning mobile radio on the job (my previous experience was microwave) and deciding price, performance and quality trade-offs in hardware.

David Durstine
Public Service Company of Colorado
Denver

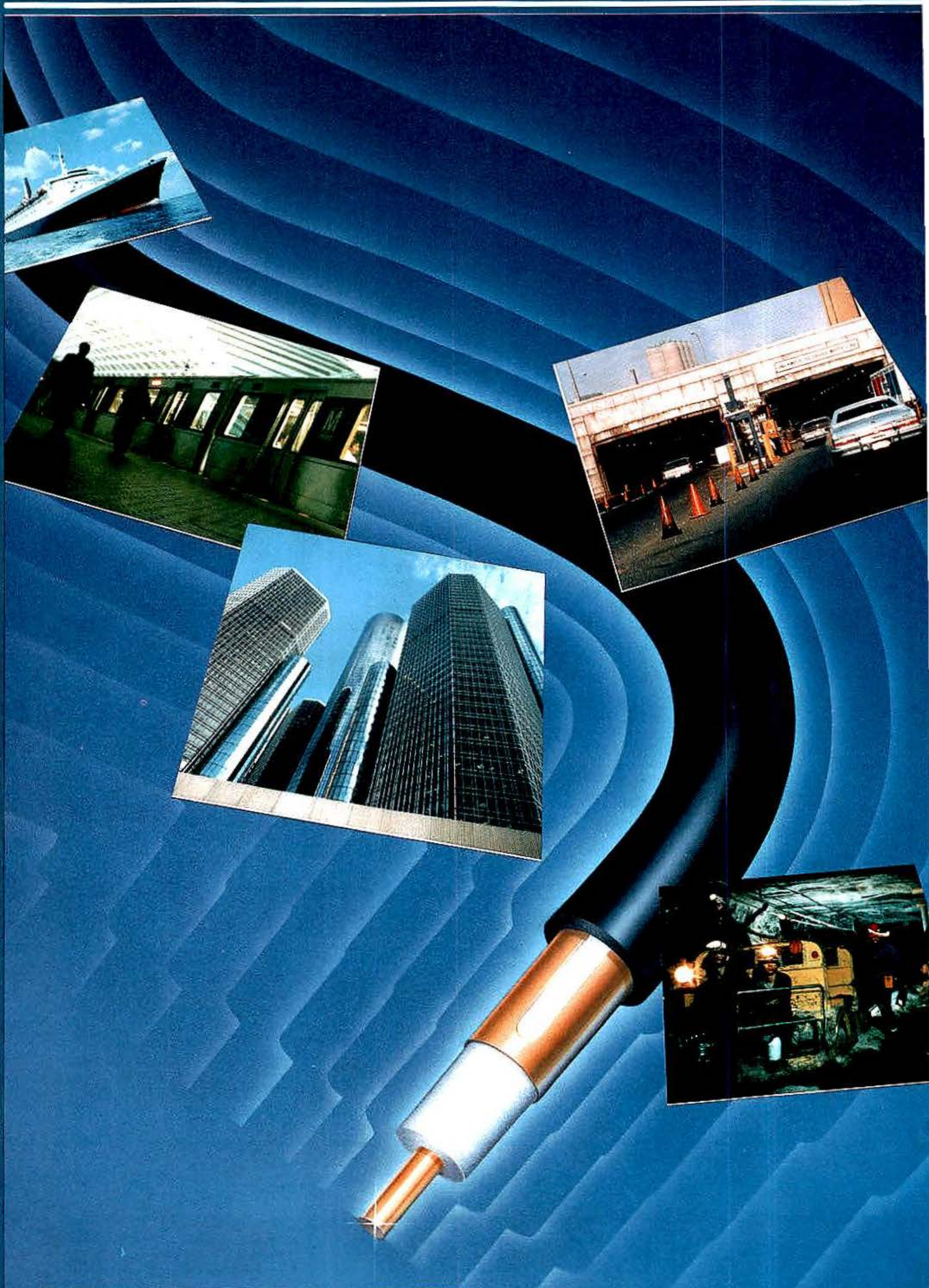
The toughest problems to solve are component-level repair and radio installations in small cars.

Adam Siegel
Electronics Technician
New York

The most interesting article in the October 1988 issue is "Lightning Protection Devices: How Do They Compare?"

The toughest problems are intermod problems in antenna combiners and multiplexers, and VHF frequency congestion.

Sgt. Bob Williamson
Montgomery Co., Sheriff Department
Conroe, TX



Use coaxial cable to communicate where antennas cannot go

Part 1—Radiating coaxial cable is well suited to communications in tunnels, mines, railway systems and ships, where traditional antennas are impractical. Installation is simple if you follow a few simple rules.

By Udo Bode

With a bewildering array of telecommunications devices available, most Americans believe we should be able to exchange information with anyone, anywhere, at almost any time. Unfortunately, there are some places, such as highway tunnels, railcars, mines and surface ships in which communications are difficult to establish. Since traditional means of transmitting and receiving signals are impractical, radiating coaxial cable is increasingly viewed as a practical solution in these physically constricting environments.

The cable can handle simultaneous transmission and reception of RF signals over short distances. Virtually any service can be accommodated—cellular telephone, mobile radio, paging and any other service that operates below about 1,700MHz. A complete transmitting and receiving system requires a receiver, low-power transmitter, diplexer, feed cable, terminations and one or more couplers (or splitters) to bring signals to and from the cables once they are installed.

The goal is to produce consistent signal strength everywhere the cable reaches. Although this is not too difficult, you must consider attenuation and receiver sensitivity important factors—right from the start. In this article, the mechanical and electrical properties of commercially available cable are discussed. In Part 2 of this article, calculations that must be made to ensure optimum performance and provide some specific examples of how these characteristics affect system performance are addressed.

Bode is director of engineering at Cablewave Systems, a division of Radio Frequency Systems, North Haven, CT.

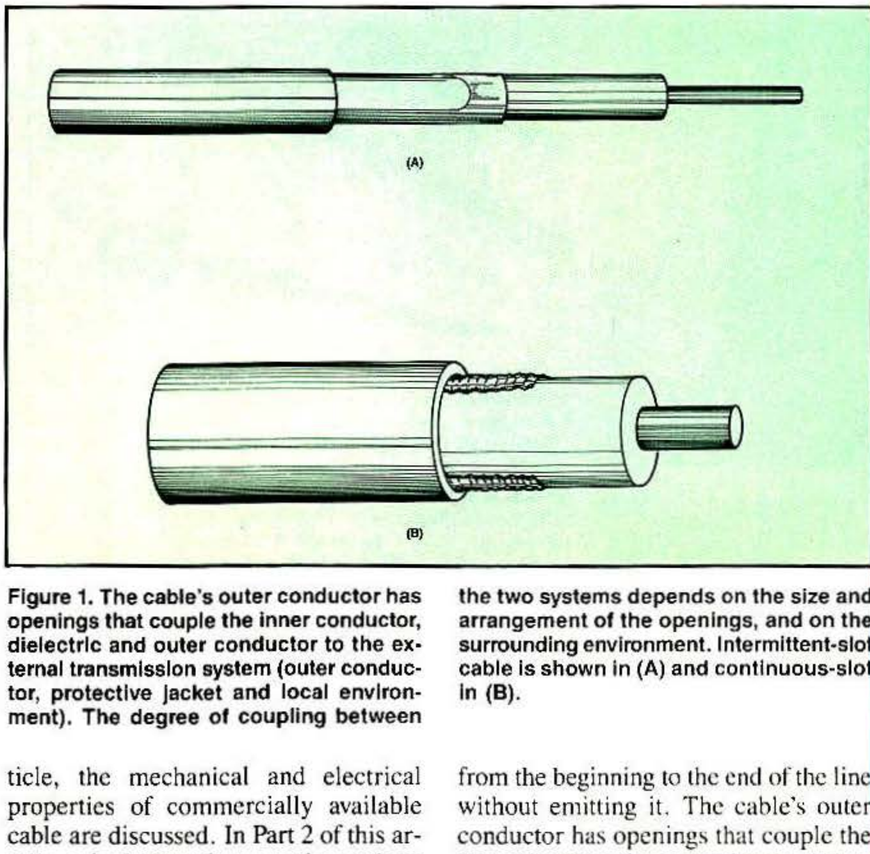


Figure 1. The cable's outer conductor has openings that couple the inner conductor, dielectric and outer conductor to the external transmission system (outer conductor, protective jacket and local environment). The degree of coupling between the two systems depends on the size and arrangement of the openings, and on the surrounding environment. Intermittent-slot cable is shown in (A) and continuous-slot in (B).

The specially designed cable does exactly the opposite of what a cable normally is expected to do. That is, it emits a signal in a relatively controlled pattern, rather than transferring a signal from the beginning to the end of the line without emitting it. The cable's outer conductor has openings that couple the internal system (inner conductor, dielectric, outer conductor) to the external transmission system (outer conductor, protective jacket, local environment). The degree of coupling between the two systems depends on the size and arrangement of the openings, and on the surrounding environment. (See Figure 1 above.)

Such cables make possible the

transmission of messages from a fixed station to a mobile one in the vicinity of the cable and vice versa. Several mobile stations can exchange messages through a fixed station. Apart from the openings in the outer conductor, the cable's construction resembles that of ordinary RF cable. Standard impedances are 50Ω and 75Ω. Thus these cables are directly compatible with standard cable, connectors and receiver and transmitter hardware used to construct the system base station.

Transmission characteristics

The transmission path from a fixed base station a mobile station antenna always consists of an "inner" and "outer" transmission system. The inner system includes the cable components minus the jacket. The outer system includes the outer conductor of the coax, the jacket and the cable's surrounding outside environment, including all nearby reflective or conductive elements such as cable mounting rails, pipes, flooring and walls. The characteristics of both systems are considered in the installation.

The inner transmission system characteristics can be considered similar to standard RF cable. But the insertion loss in radiating cables is always greater than the loss in standard RF cables of similar construction. The insertion loss is directly related to the openings in the cable's outer conductor. (See Figure 2 on page 14).

The transmission path from a fixed base station to a mobile station antenna always consists of an 'inner' and 'outer' transmission system.

Any power emitted from the slots is no longer available to the inner system for propagation along the cable's length. Dielectric loss is produced by the protective jacket that covers the openings in the outer conductor. This manifests itself as increased insertion loss, especially when the openings constitute a large fraction of the total outer conductor surface area.

In addition to loss from the protective jacket, the environment can add to the insertion loss when the cable is mounted on or close to wall surfaces. Cable with large slot openings should be mounted a reasonable distance (at least 3 inches) from any nearby support surface. Accumulations of road-maintenance salt on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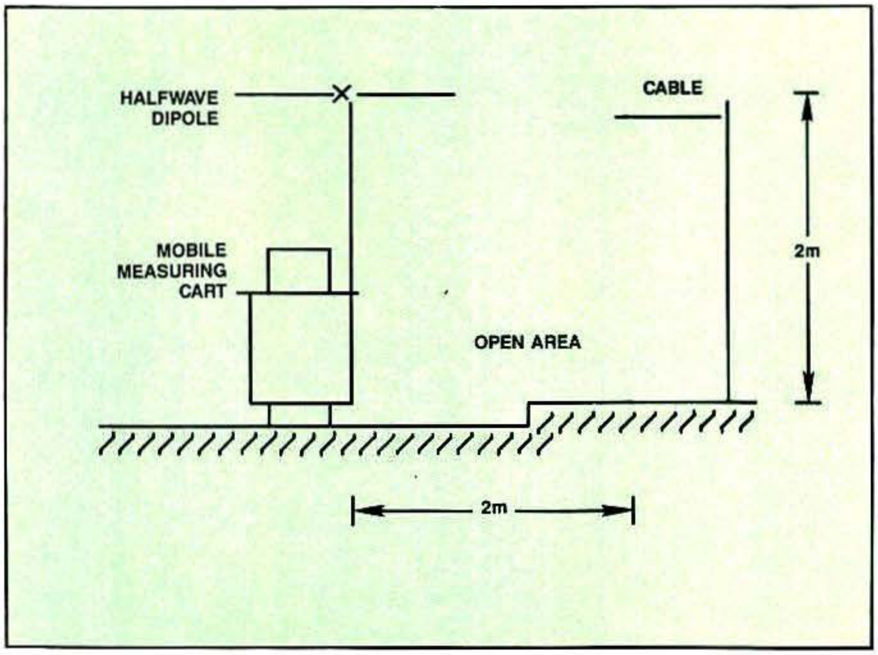

Figure 2. Published figures for coupling loss for leaky cables are derived from tests using a movable halfwave dipole antenna located 2m from the cable run, with the cable itself supported 2m away from the ground surface. Data are carefully recorded over a 100m length of the installed cable.

cables used in automobile tunnels can also contribute to loss. Cables are available with small groups of slots, randomly irregular small-slit construction to minimize this problem.

Radio energy released by the cable reaches a portable transceiver's antenna by different routes, as do signals transmitted by the mobile unit that are picked up by the cable. Precise propagation paths, and therefore precise propagation path loss, is difficult to predict because the signal level picked up by an antenna near the cable cannot be calculated exactly. Conservative estimates of cable and environmental loss, receiver sensitivity and expected signal strength must be used to prevent problems in actual installations.

Countering coupling loss

An important variable of these cable systems is coupling loss. This is the difference in decibels between the signal level in the inner transmission system and the signal level at the antenna

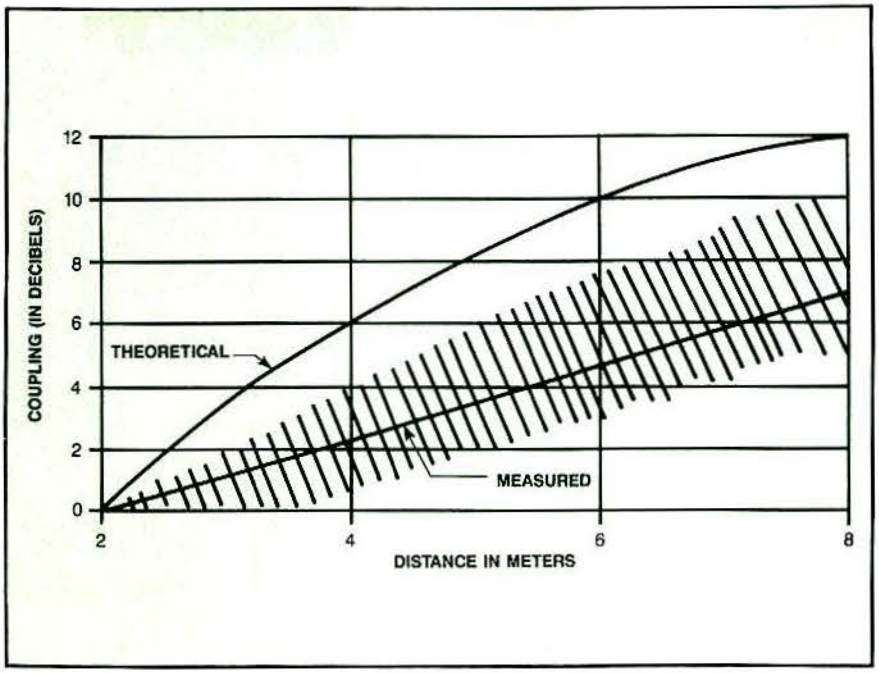

Figure 3. Using the test setup of Figure 2, these results were obtained, based on a variable distance from 2m to 8m between the cable and the movable test vehicle. The hatched area represents the dispersion of the measurement results. Both theoretical and measured results are presented.

located a specific distance from the cable. As a result of the unpredictable propagation conditions that can exist between the cable and the antenna, the coupling loss varies when the receiving antenna is moved radially to or in parallel with the installed cable. Significant factors that affect coupling loss (other than cable construction) are operating frequency, type and orientation of the mobile antenna and, assuming the antenna is mounted on a truck or car, effects traceable to the vehicle's outer skin, such as absorption and reflection.

Comparing cables

To help communications system installers compare radiating cable types, coupling loss is measured under carefully defined conditions. The result of such measurements is called the cable coupling loss and is given in the manufacturer's published technical data. The standard measurement system consists of a vehicle that tracks a line parallel to

the cable while transmitting a signal. (See Figure 3 on page 16.)

During the measurement, the car is driven parallel to the cable and the difference between the transmitter level at the beginning of the cable and the level at the receiver's halfwave dipole antenna is recorded as a function of position for several frequencies. When the curves are evaluated, the percentage of positions along the length of the cable at which the coupling loss is smaller than a given value can be calculated. A comprehensive evaluation of a large number of such measurements for various cables and various frequencies produces an interesting display of probability (See Figure 3). The curve on this diagram is the probability that a given coupling loss is not exceeded along a given length of cable. The hatched area shows the uncertainty of such a determination. Many cables show little change in coupling loss with frequency, but for cables that show some frequency sensitivity, a nominal coupling loss correction factor must be obtained from the manufacturer's data and added to the predicted coupling loss.

Contributors to coupling loss

The type of mobile antenna used, its distance from the cable and the support structure used to mount the cable are important factors that affect coupling loss. When the distance between an RF source and an antenna doubles in free space, the field intensity drops by 6dB. Actual field measurements show that the increase in coupling loss with distance between a leaky cable and a mobile antenna is, on average, somewhat weaker than this.

Coupling loss data have been gathered using quarterwave groundplane antennas and quarterwave vertical antennas in place of the halfwave dipole. (Minimum coupling loss was recorded using the halfwave dipole.) When these shorter antennas are used, an additional correction term (in decibels) must be added to account for the greater coupling loss.

If the cable is placed directly on a tunnel wall or across open ground, a substantial increase in coupling loss might result. For example, cable laid directly across a stucco wall exhibited as much as 15dB more coupling loss than measured in the standard cable and antenna test setup. But this "extra" coupling loss dropped to less than 3dB when the cable was held just 7cm away from the wall surface. The advantages of mounting cable away from wall or ground surfaces becomes significant in critical situations. Mounting materials are readily available that will separate the cable properly while making a negligible contribution to coupling loss.

These are just a few of a radiating cable's characteristics. Part 2 of this series covers specific applications for the cable and examines the calculations necessary to determine the characteristics it will have. When the recommended steps are taken, cable installation is simple and straightforward, because the "think work" is finished.

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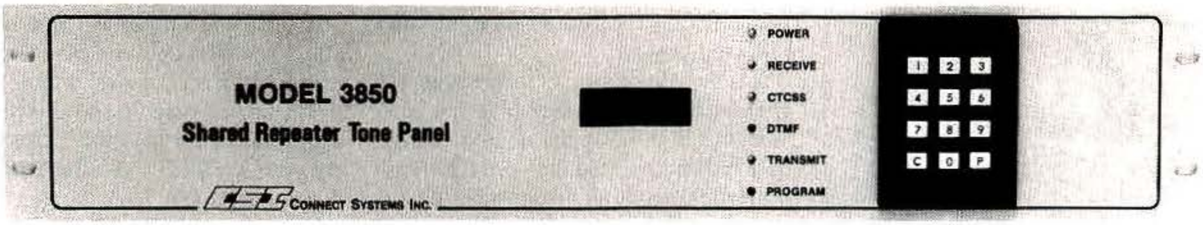

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Base station feedline performance testing

There is a lot more to the feedline in a base station antenna system than meets the eye. Use these test and measurement techniques to monitor and to maintain feedline performance as the cable ages.

By Harold Kinley, CET

The standing wave ratio (SWR) measurement, or forward and reflected power measurement, is the single most important measurement used by technicians in testing the antenna and associated feedline. Antenna defects that affect gain and directivity usually cause an SWR increase, so a practical understanding of SWR can help you to troubleshoot antenna and feedline defects.

The box on page 22 defines abbreviations used in the following discussion of antenna and feedline tests, and in applying formulas.

Photo 1. The Bird model 43 Thruline wattmeter is a highly directional wattmeter of the type commonly used by land mobile radio technicians.

Wattmeter

Land mobile radio technicians commonly use an in-line directional wattmeter such as the unit shown in Photo 1 at the left. The in-line wattmeter is highly directional, so it can be used to measure a feedline's forward and reflected power.

It is the comparison of reflected power (*Pr*) with forward power (*Pf*) that is so valuable in judging the degree of mismatch that may exist between the transmitter and feedline or between the antenna and feedline (or, for that matter, between any power source and load). Technicians usually think of reflected and forward power rather than SWR units. The comparison of reflected and forward power is expressed as a power ratio (r), where:

$$r = Pr/Pf.$$

The reflected/forward power ratio often is expressed as *percent reflected power (R)*, where

$$R = 100(Pr/Pf) = 100r.$$

There is a direct mathematical relationship between SWR and the reflected/forward power ratio (r). Equation 5 in the box on page 22 converts SWR units (S) to the reflected/forward power ratio (r). Conversely, Equation 4 converts the reflected/forward power ratio (r) to SWR units (S). The graph in Figure 1 on page 24 converts SWR units (from 1 to 10) to *percent reflected power* and vice versa.

If you are used to working with reflected/forward power readings (rather than SWR), you do not need to convert the reflected/forward power readings to SWR to evaluate the degree of impedance mismatch. Reflected and forward power readings alone let you estimate the SWR, once you have experience. Still, there are times when it is desirable to convert between SWR units and reflected/forward power ratios.

The box on page 26 shows typical scientific calculator keystrokes that convert between SWR (S) and reflected/forward power ratios (r).

Feedline attenuation

A feedline's attenuation factor usually is expressed in decibels per 100 feet of coaxial cable. Attenuation increases at higher radio frequencies.

Measuring a feedline's attenuation usually is inconvenient because it involves climbing a tower. But when the tower must be climbed anyway, take the opportunity to measure the feedline attenuation. Measure power at the feedline input and output. Convert the power ratio to decibels. Divide the decibel figure by feet and multiply by 100 to reveal the attenuation in decibels per 100 feet. Compare the attenuation with the cable

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manufacturer's specifications to see whether the actual attenuation is normal or excessive.

Sunlight, moisture and other environmental conditions degrade feedline performance as the cable ages. Degradation increases attenuation. In recent years, improved feedline manufacturing has provided coaxial cable that is more resistant to environmental effects, cable that gives reliable service for longer periods.

Figure 2 on page 30 shows the procedure used to check feedline attenuation. At (A), measure forward power at the feedline input and record the reading. At (B), measure forward power at the feedline output (dummy load or antenna) and record the reading. (C) shows two ways to use the readings to calculate the attenuation in decibels.

Figure 3 on page 30 shows another way to measure attenuation, based on the highly directional characteristics of the in-line wattmeter.

Wattmeter accuracy

First, check the wattmeter accuracy by connecting one side to the transmitter and leaving the other side unterminated. Forward and reflected power readings should be equal or so close to equal that you cannot see any difference. A difference between these readings affects the accuracy of test results.

At (A), connect a long, unterminated feedline to the wattmeter. Record the forward power reading.

At (B), record the reflected power reading.

Use the calculations at (C) to determine the feedline attenuation. Use the divisor 2 because the signal is attenuated twice—once as it travels to the end of the line and once as it returns. Measurement accuracy does not depend on the wattmeter's *absolute* readings. Rather, it depends on the *relative* readings.

For example, if the forward power reading is 5% low and the reflected power reading also is 5% low, accuracy is unaffected. But if the forward power reading is 5% low and the reflected power reading is 5% high, accuracy *is* affected.

Feedline loss vs. SWR

On a theoretical, lossless feedline, SWR is the same at all points along the line. Actually, all feedlines have some attenuation distributed uniformly along their entire lengths. *Any attenuation between the reflection point and the source reduces SWR at the source.*

Figure 4 on page 32 shows the effect feedline attenuation has on SWR. Total feedline attenuation is 3dB, divided into 0.25dB segments. Notice that at the end of each segment (away from the reflection point), SWR becomes smaller. SWR reduction is smooth and gradual

Abbreviations

R = percent reflected power
Pf = forward power
Pr = reflected power at antenna
Pf_1 = forward power at transmitter

Pf_2 = forward power at antenna
Pr_1 = reflected power at transmitter
Pr = reflected power at antenna
r = power ratio (Pr/Pf)

r_1 = power ratio at transmitter
r_2 = power ratio at antenna
S = standing wave ratio
S_1 = standing wave ratio transmitter

S_2 = standing wave ratio at antenna
L = normal feedline loss in decibels
L_A = additional feedline loss in decibels caused by SWR on the feedline
L_T = total feedline loss

Feedline equations

(1) $r = Pr/Pf$

(2) $R = 100(r)$

(3) $r = R/100$

(4) $S = \dfrac{1 + \sqrt{r}}{1 - \sqrt{r}}$

(5) $r = [(S - 1)/(S + 1)]^2$

(6) $S_2 = \dfrac{1 + \sqrt{10^{(L/5)} r_1}}{1 - \sqrt{10^{(L/5)} r_1}}$

(7) $S_1(max) = \dfrac{1 + \sqrt{10^{(L/5)}}}{1 - \sqrt{10^{(L/5)}}}$

(8) $L_T = 10\log[(Pf_1 - Pr_1)/(Pf_2 - Pr_2)]$

(9) $L_A = L_T - L$

(10) $L_A = 10\log[(1 - r_1)/(1 - r_2)]$

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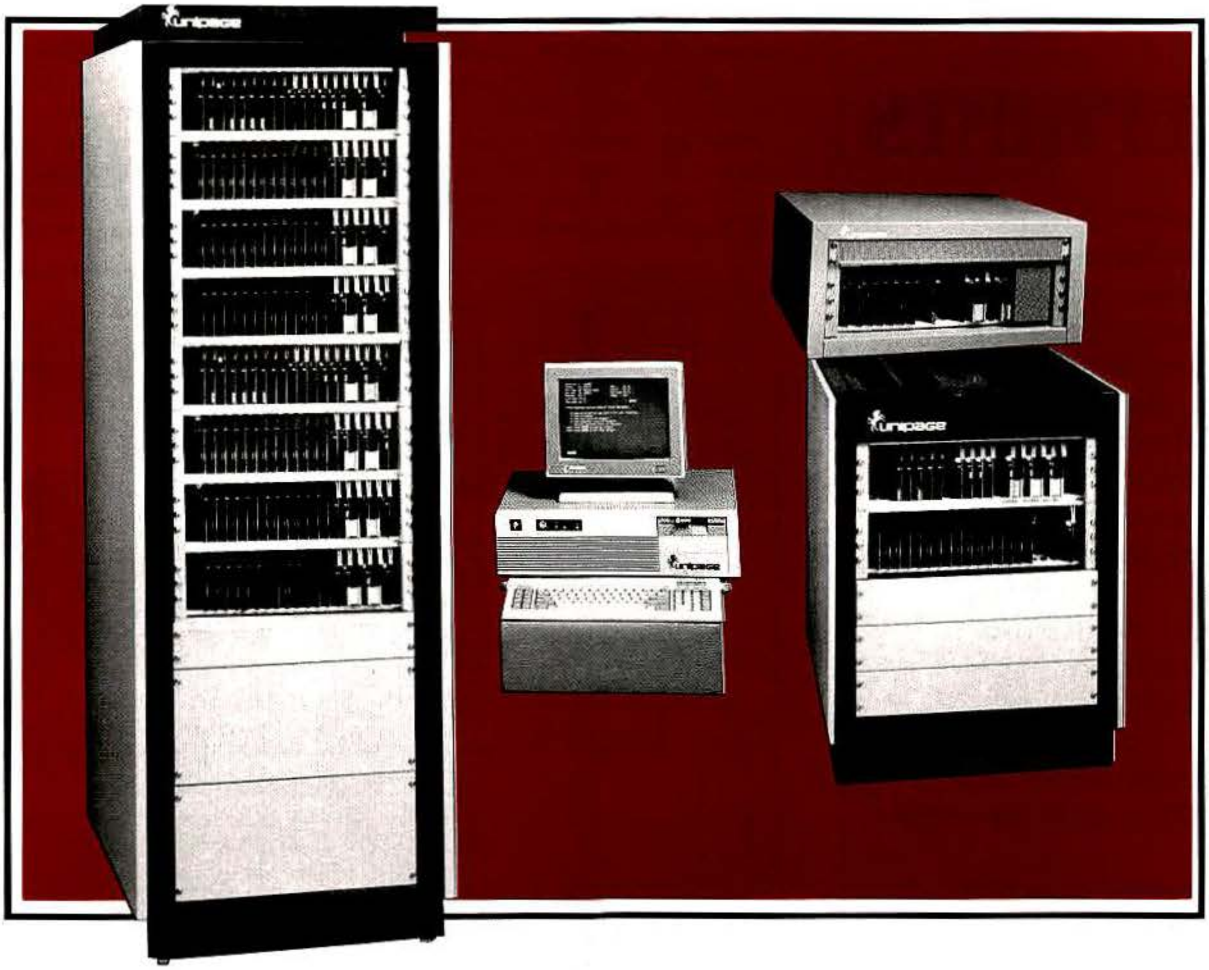

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because feedline attenuation is distributed evenly.

Study Figure 5 on page 34 to understand why attenuation reduces SWR at the source. At the feedline input (A), forward power is 100W. At (B), forward power is reduced to 50W, a 3dB loss caused by attenuation between points (A) and (B). At (C), forward power is reduced to 25W, another 3dB loss caused by attenuation between points (B) and (C). At (C), SWR is 3.

The graph in Figure 1 shows that an SWR of 3 corresponds to 25% reflected power, so the reflected power is:

$$0.25 \times 25W = 6.25W.$$

As the reflected power returns along the line toward the source, it is attenuated once again. The 6.25W reflected power is reduced to 3.125W at (B) and to 1.5625W at (A). You can determine the SWR at the three points by calculating the power ratio *r* (*Pr/Pf*) and by substituting it into Equation 4 on page 22. (See the box on page 26 for calculator keystrokes; use sequence A.)

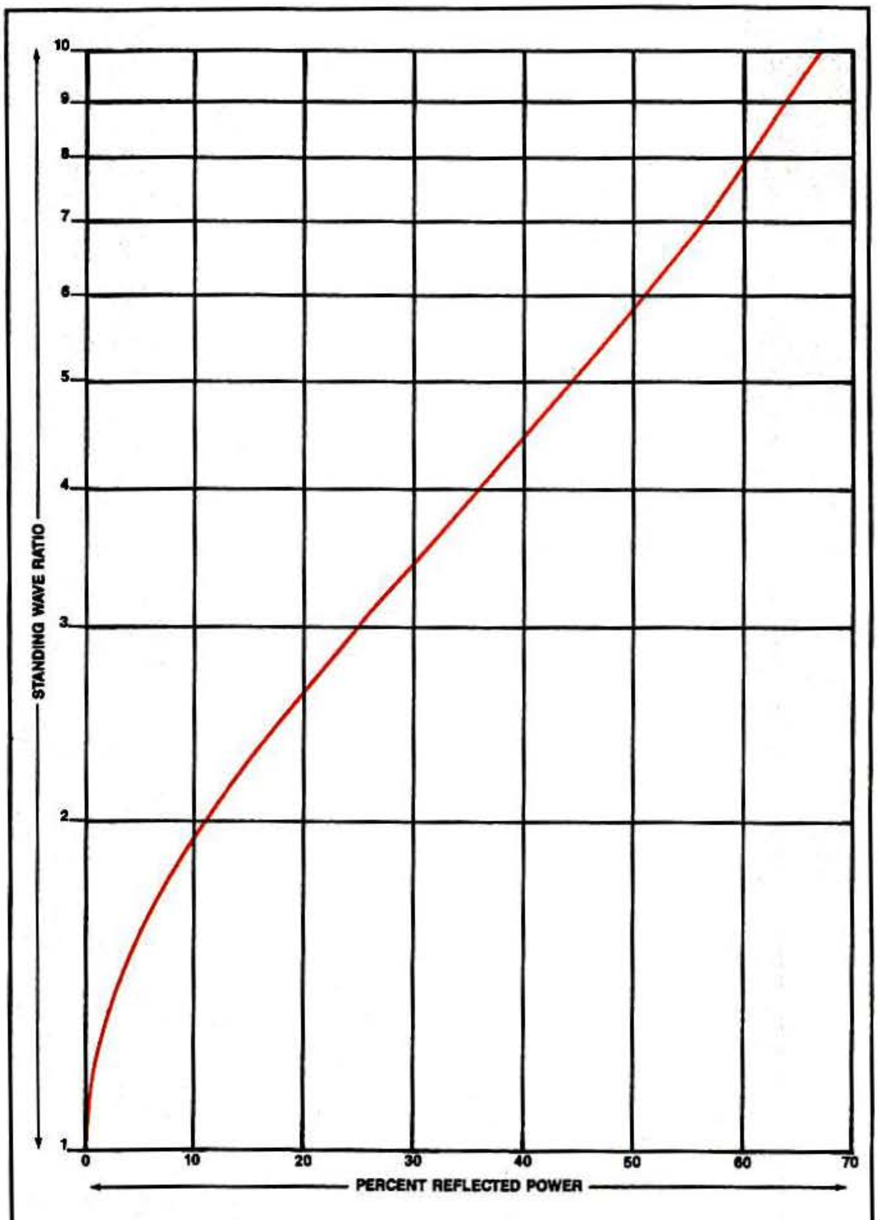

Figure 1. This graph is handy for making conversions between percent reflected power and standing wave ratio (SWR).

Use the graph in Figure 6 on page 36 to find the SWR at the antenna from the SWR (or percent reflected power) at the transmitter for various values of feedline attenuation.

SWR increases feedline loss

In the example in Figure 5, the feedline's one-way attenuation is 6.02dB. Forward power is reduced 6.02dB as it travels from (A) to (C). But reflected power causes another power loss between (A) and (C). Power absorbed or dissipated in a load (or feedline) is the *net* power, or the difference between forward and reflected power. At (A), net power is:

100W − 1.5625W = 98.4375W

At (B), net power is:

50W − 3.125W = 46.875W

At (C), net power delivered to the load is:

25W − 6.25W = 18.75W

Thus, the *total* decibel loss between (A) and (B) is:

10 log (98.4375/46.875)

= 3.22dB

Notice that this is 0.21dB *more* than the normal feedline attenuation, which is one-half of 6.02dB, or 3.01dB. The *total* decibel loss between (B) and (C) is:

10 log (46.875/18.75)

= 3.98dB

This is 0.97dB more than the normal feedline attenuation.

These calculations prove that standing waves on the feedline increase feedline attenuation to a level greater than normal attenuation under matched-line conditions. The amount of feedline attenuation increase depends on the SWR and the magnitude of losses under matched-line conditions. The higher the attenuation under matched-line conditions, the greater the additional attenuation caused by a given SWR; and the greater the SWR, the higher the additional attenuation over matched-line loss.

Scientific calculator keystrokes

Feedline/SWR calculations and conversions

(A) To convert power ratio (*r*) to SWR (*S*) enter:

r [√] [M+] [+] 1 [=] [÷] [(] 1 [−] [MR] [)] [=]

<READOUT>

Example: An in-line wattmeter indicates 100W forward power and 25W reflected power at the feedline input. What is the SWR (*S*) at this point?

Solution: First find *r* from (*Pr/Pf*): *r* = 25/100 = 0.25. Now enter:

.25 [√] [M+] [+] 1 [=] [÷] [(] 1 [−] [MR] [)] [=]

< 3>

(B) To convert SWR (*S*) to power ratio (*r*) enter:

S [−] 1 [=] [÷] [(] *S* [+] 1 [)] [=] [INV] [√] [=]

<READOUT>

Example: The SWR (*S*) at a certain point on a feedline is 2.5. What is the power ratio (*r*) at this point?

Solution: Enter:

2.5 [−] 1 [=] [÷] [(] 2.5 [+] 1 [)] [=] [INV] [√] [=]

<0.183673469>

(C) To calculate the SWR (S_2) at the antenna, given the power ratio r_1 at the transmitter and the feedline loss, enter:

L [÷] 5 [=] [INV] [LOG] [X] r_1 [=] [√] [M+] [+] 1 [=] [÷] [(] 1 [−] [MR] [)] [=] <READOUT>

Example: An in-line wattmeter is connected to the input of a feedline. The forward power reading is 50W and the reflected power reading is 7.5W. According to the feedline specifications, its attenuation at the operating frequency is 1.0dB per 100 feet. The feedline length is 250 feet. What is the SWR (S_2) at the antenna?

Solution: First, r_1 = 7.5/50 = 0.15. Next, the feedline attenuation (*L*) = 250 × (1/100) = 2.5dB. Now enter:

2.5 [÷] 5 [=] [INV] [LOG] [X] .15 [=] [√] [M+] [+] 1 [=] [÷] [(] 1 [−] [MR] [)] [=] <5.425179586>

(D) To find the maximum SWR (S_1) that will be seen at the transmitter with a worst-case mismatch at the antenna, given the feedline loss (*L*), enter:

L [+/−] [÷] 5 [=] [INV] [LOG] [√] [M+] [+] 1 [=] [÷] [(] 1 [−] [MR] [)] [=] <READOUT>

Example: A worst-case mismatch exists at the antenna end of a feedline. The *normal* attenuation of the line is 3dB. What is the SWR (S_1) at the transmitter?

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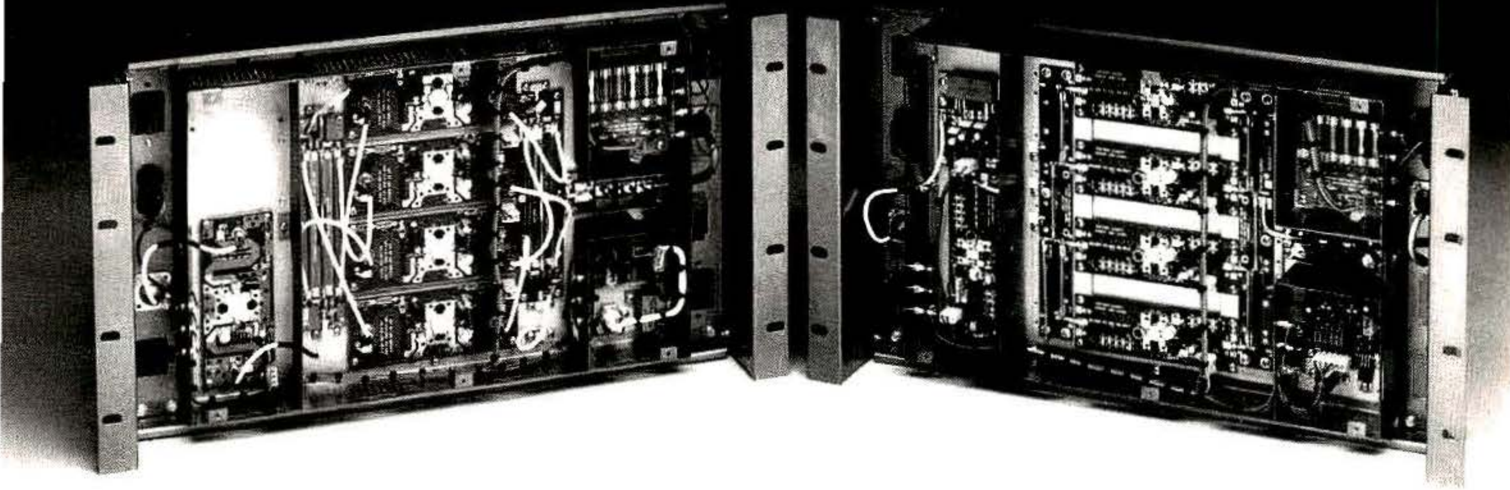

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The graph in Figure 7 on page 38 correlates additional attenuation with matched-line attenuation for various SWR levels.

Additional line attenuation

If you know the normal line attenuation from the manufacturer's specifications, you can calculate the additional line attenuation caused by SWR in the following manner.

(1) Measure forward and reflected power at the transmitter.

(2) Calculate r_1 (power ratio at transmitter) from

$r = (Pr/Pf)$.

(3) Use Equation 6 to calculate SWR at the antenna (S_2). (See sequence C in the box on page 26 for calculator keystrokes.)

(4) Use Equation 5 to calculate r_2 (power ratio at the antenna) from (S_2).

(5) Substitute r_1 and r_2 into Equation 10 to find the additional attenuation caused by SWR. (See sequence F in the box below for calculator keystrokes.)

These calculations reveal the additional line attenuation caused by SWR if the feedline itself is not defective, meaning that the *normal* feedline attenuation is approximately equal to the manufacturer's specification and that the only reflection is from the antenna at the end of the feedline.

Notice that the greatest additional attenuation occurs on the section of line where the SWR is highest. Refer once again to Figure 4. The chart at (C) shows the extra attenuation caused by standing waves on the feedline. Notice that at points farther removed from the reflection point, *extra* loss and *total* loss decrease at each segment down the line.

Solution: Enter:

3 [+/-] [÷] 5 [=] [INV] [LOG] [√] [M+] [+] 1 [=] [÷] [(] 1 [-] [MR] [)] [=] <3.009520474>

(E) To find the *total* feedline loss when the forward and reflected power at each end are known:

Pf_1 [-] Pr_1 [=] [÷] [(] Pf_2 [-] Pr_2 [)] [=] [LOG] [X] 10 [=] <READOUT>

Example: At the *input* to a feedline, an in-line wattmeter indicates 100W forward power and 1.55W reflected power. At the feedline *output* (at the antenna), the wattmeter indicates 25W of forward power and 6.25W of reflected power. Calculate the *total* loss (in decibels) of the feedline.

Solution: Enter:

100 [-] 1.55 [=] [÷] [(] 25 [-] 6.25 [)] [=] [LOG] [X] 10 [=] <7.202144484>

(F) To find the *additional* feedline loss due to SWR, given the *power ratio* (r) at each end, enter:

1 [-] r_1 [=] [÷] [(] 1 [-] r_2 [)] [=] [LOG] [X] 10 [=] <READOUT>

Example: The power ratio (*Pr/Pf*) at the antenna is 0.563. The power ratio at the transmitter is 0.282. Calculate the *additional* feedline loss due to SWR.

Solution: Enter:

1 [-] .282 [=] [÷] [(] 1 [-] .563 [)] [=] [LOG] [X] 10 [=] <2.156430073>


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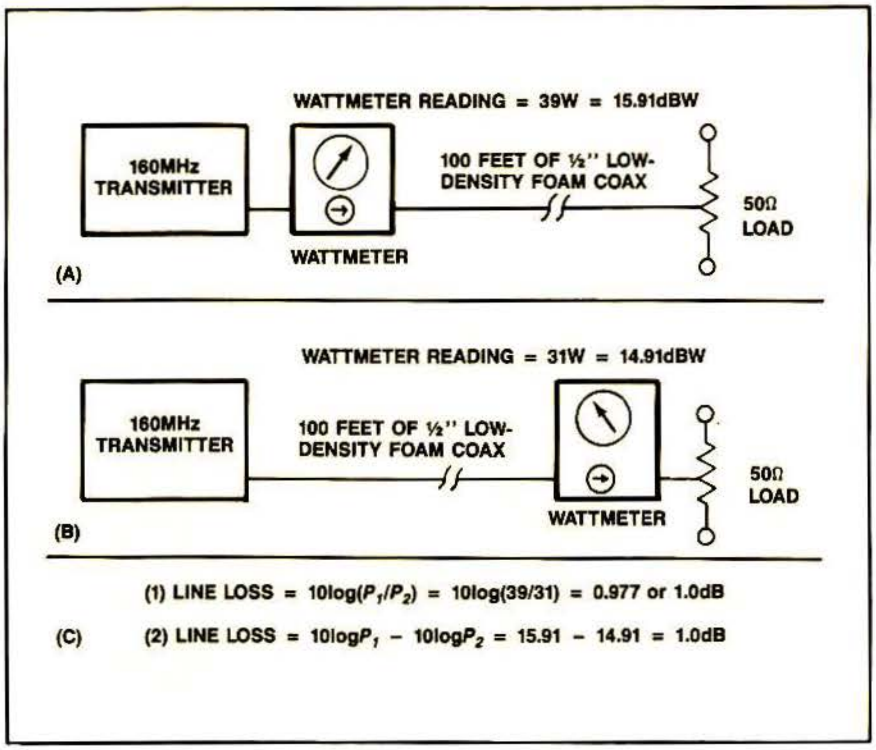

Figure 2. (A) Use a wattmeter to measure power at the feedline input. (B) Use a wattmeter to measure power at the feedline output. (C) Use either equation and the two measurements to calculate feedline attenuation.

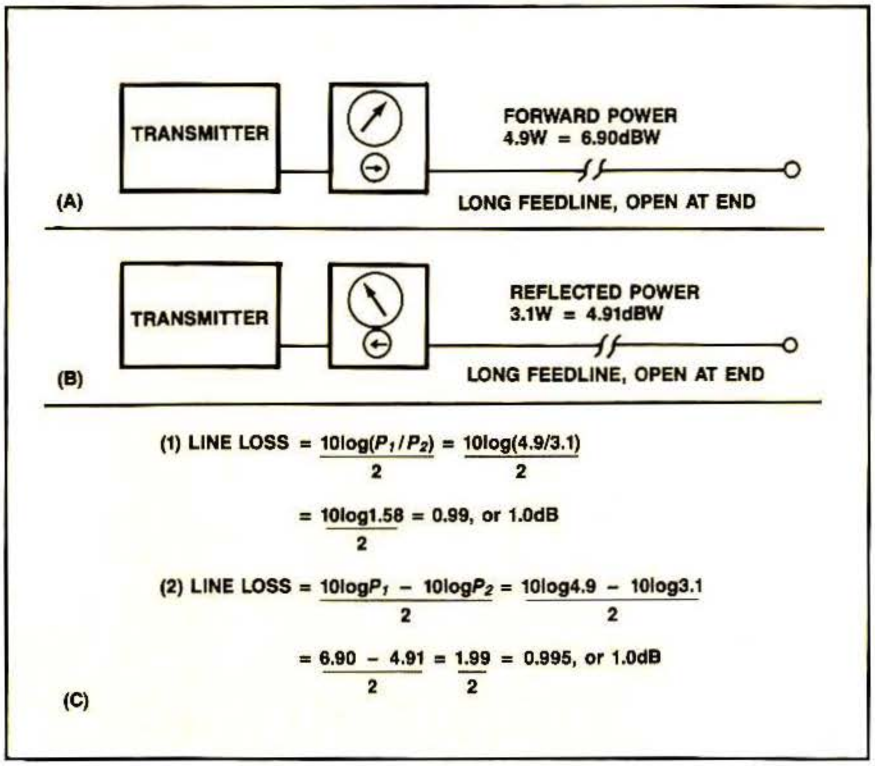

Figure 3. Use a directional wattmeter to find the feedline attenuation by leaving the line open at one end and making forward (A) and reflected (B) power measurements at the feedline input. Then use the measurements to calculate feedline attenuation (C).

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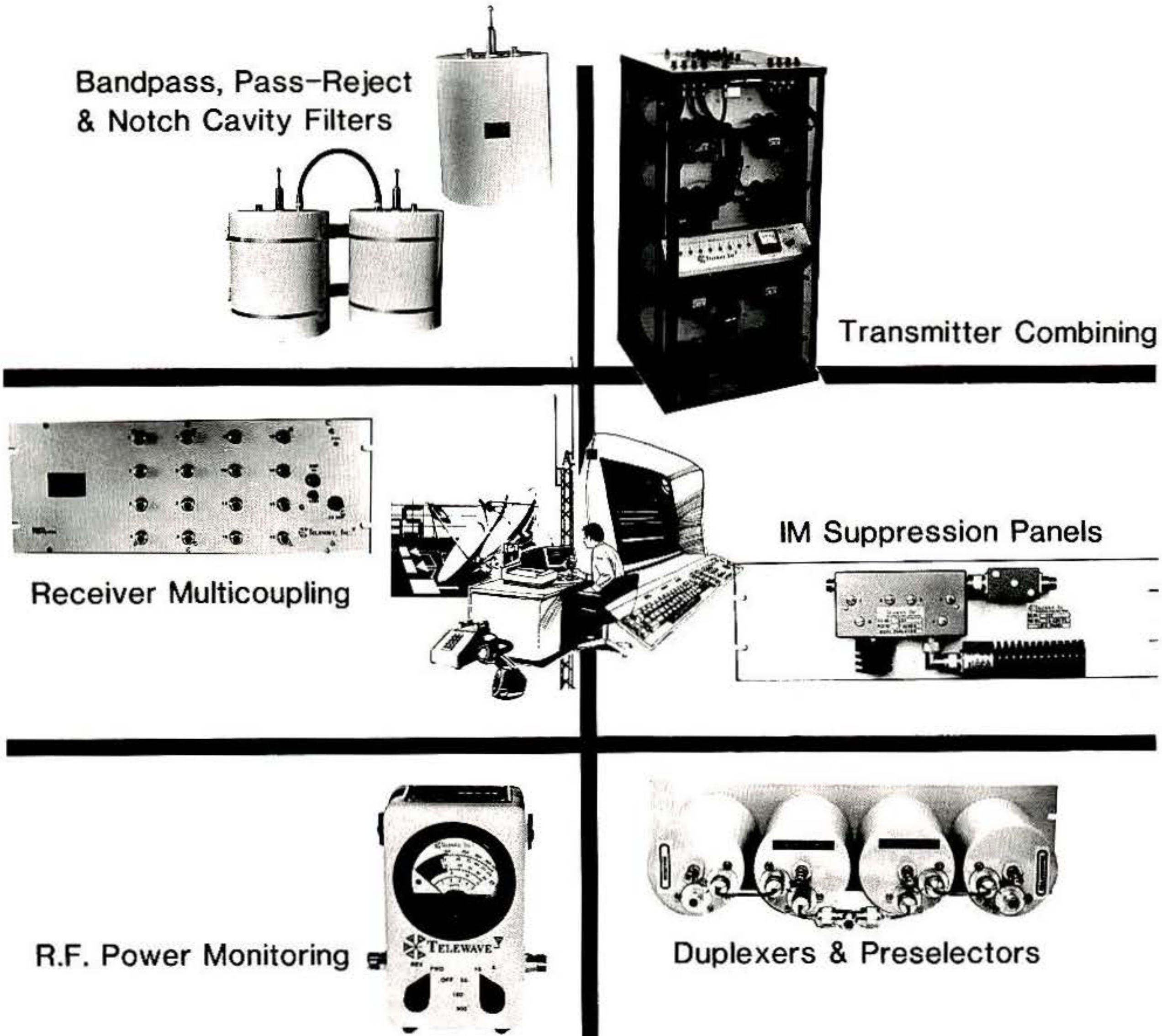

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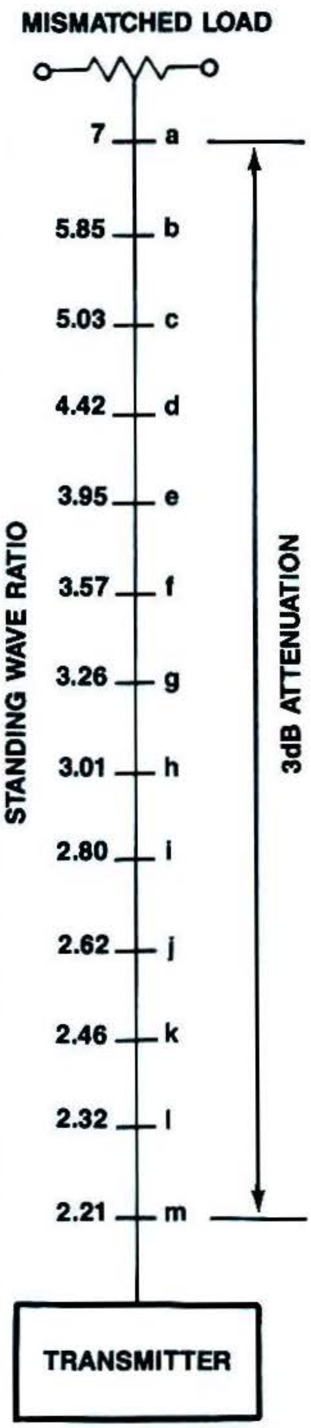

(A)

SWR	PERCENT REFLECTED POWER
2.21	14.1
2.32	15.8
2.46	17.8
2.62	20.0
2.80	22.4
3.01	25.1
3.26	28.2
3.57	31.6
3.95	35.5
4.42	39.8
5.03	44.7
5.85	50.1
7.00	56.3

(B)

SEGMENT	EXTRA LOSS (dB)	TOTAL LOSS (dB)
a to b	0.576	0.826
b to c	0.446	0.696
c to d	0.369	0.619
d to e	0.300	0.550
e to f	0.255	0.505
f to g	0.211	0.461
g to h	0.184	0.434
h to i	0.154	0.404
i to j	0.132	0.382
j to k	0.118	0.368
k to l	0.104	0.354
l to m	0.087	0.337
a to m	2.936	5.936

(C)

Figure 4. Total feedline (A) loss is 3dB. The feedline is divided into 0.25dB segments to illustrate how the SWR changes with attenuation along the length of the feedline. Table (B) converts SWR to percent reflected power. Table (C) shows the *extra loss* and the *total loss* for each feedline segment and for the entire feedline.

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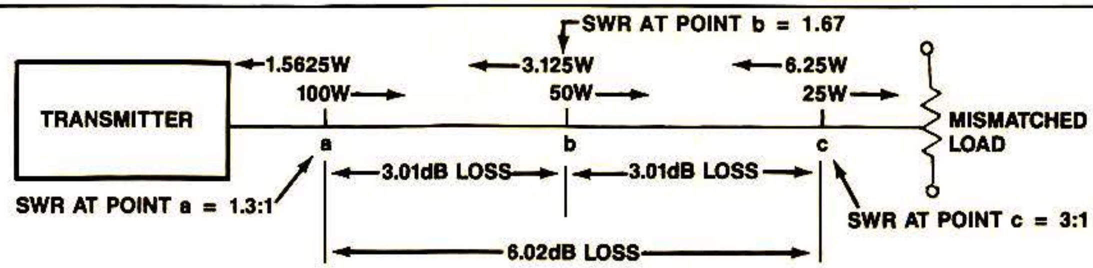

	TRANSMISSION LINE LOSSES (dB)		
FROM	NORMAL	EXTRA	TOTAL
a to b	3.01	0.21	3.22
b to c	3.01	0.97	3.98
a to c	6.02	1.18	7.20

(B)

Figure 5. SWR causes extra loss in the feedline (A) because reflected power also is attenuated by normal feedline attenuation. Table (B) shows how feedline losses are distributed.


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The extra loss approaches zero as the total loss approaches normal line attenuation (0.25dB).

Maximum SWR

Even with a worst-case mismatch at the feedline output, there is a limit to the maximum SWR seen at the feedline input. The greater the feedline's normal attenuation, the lower the limit on SWR at the feedline input.

Figure 8 on page 40 correlates normal feedline attenuation with the maximum SWR that will appear at the transmitter.

For example, if the normal feedline attenuation is 3dB, the highest SWR that will be seen at the transmitter is approximately 3, even with the worst possible mismatch at the feedline output. Knowing that limit can be quite helpful when it comes to troubleshooting a problem with the feedline.

For example, if a certain feedline normally has 3dB attenuation and the feedline input SWR measurement is greater than 3, the reflection point must be somewhere between the transmitter and the antenna. Why? Because there must be much less than 3dB attenuation between the feedline input and the reflection point to produce an SWR much greater than 3 at the feedline input.

Equation 7 can be used to calculate the maximum SWR at the transmitter for a given feedline attenuation. Se-

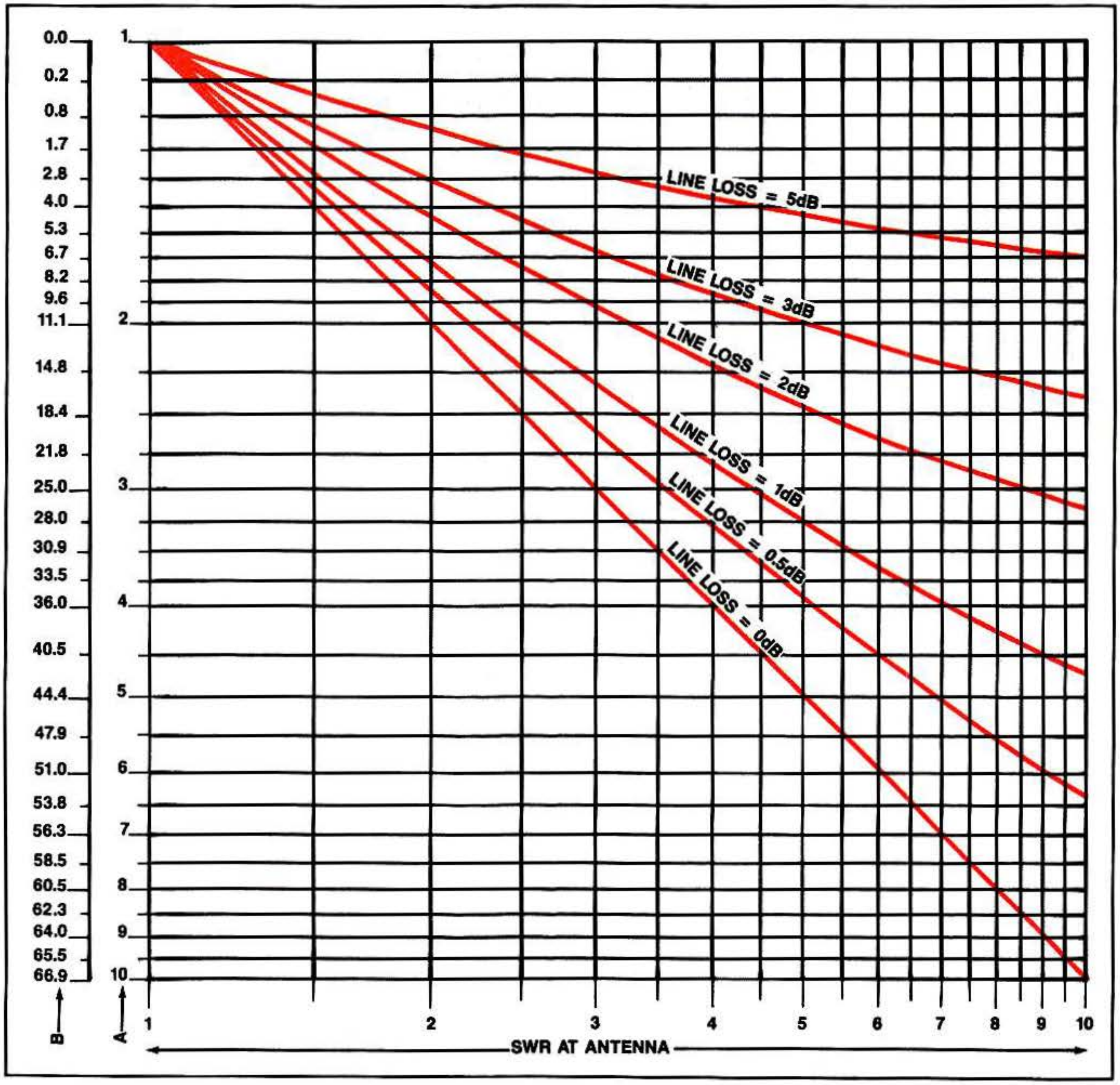


Figure 6. Use this graph to determine SWR at the antenna for various line losses from either the percent reflected power or SWR at the transmitter. The two vertical scales also serve as a simple nomograph for converting between SWR and percent reflected power. Scale A = SWR at transmitter. Scale B = corresponding reflected power.

quence D on page 26 shows the calculator keystrokes to use.

SWR at the antenna

Figure 8 has another use: to find the SWR at the antenna from the SWR at the transmitter (or vice versa) given the normal feedline attenuation.

For example, to find the SWR at the antenna when the SWR at the transmitter is 3 and the normal feedline attenuation is 1.5dB, find 3 on the vertical SWR scale, follow over to the intersection of the curve and then down to the feedline loss (horizontal scale) at 3dB. Now move down the horizontal scale 1.5dB to 1.5dB. Then move back up to the intersection of the curve and back over to the SWR (vertical) scale at approximately 5.85.

You can find SWR at the transmitter the same way, except that you move up the horizontal scale the amount of the feedline attenuation. Remember this basic rule: *SWR at the antenna is always greater than SWR at the transmitter* (assuming the only reflection point is at the antenna).

SWR and impedance

When a feedline is terminated by an impedance equal to the feedline's *characteristic impedance*, the feedline impedance at *any point* equals the feedline's characteristic impedance. But when the feedline is terminated by an

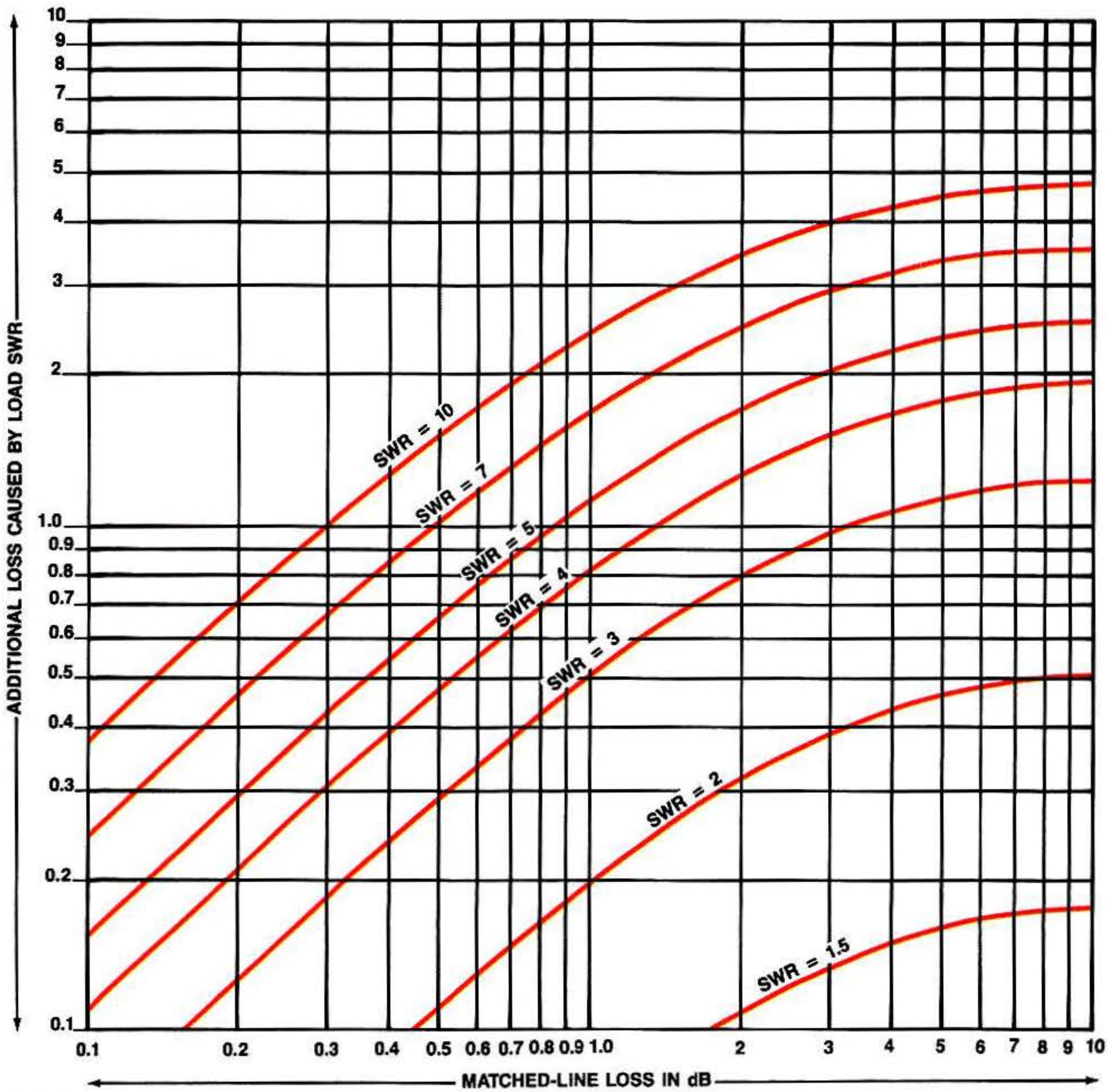


Figure 7. Use this graph to determine the *additional* line loss caused by SWR.

impedance not equal to the feedline's characteristic impedance, the feedline input impedance varies with changes in feedline length.

The greater the impedance mismatch at the load, the wider the feedline input impedance variation with changes in line length. The greatest feedline impedance change occurs with the worst mismatches: open- or short-circuits.

A short-circuit at the end of a feedline appears as an open-circuit at a point ¼-wavelength down the feedline, and it is the greatest impedance transformation that can occur on a feedline. Less severe mismatches cause smaller impedance transformations on the line.

The point of maximum impedance transformation appears at a point ¼-wavelength down the line from the mismatched load. At a point ½-wavelength down the line, the impedance equals the load impedance.

Feedlines with high SWR sometimes are called *resonant* or *tuned* feedlines. Matched lines—those with little SWR—are *non-resonant* or *untuned* lines.

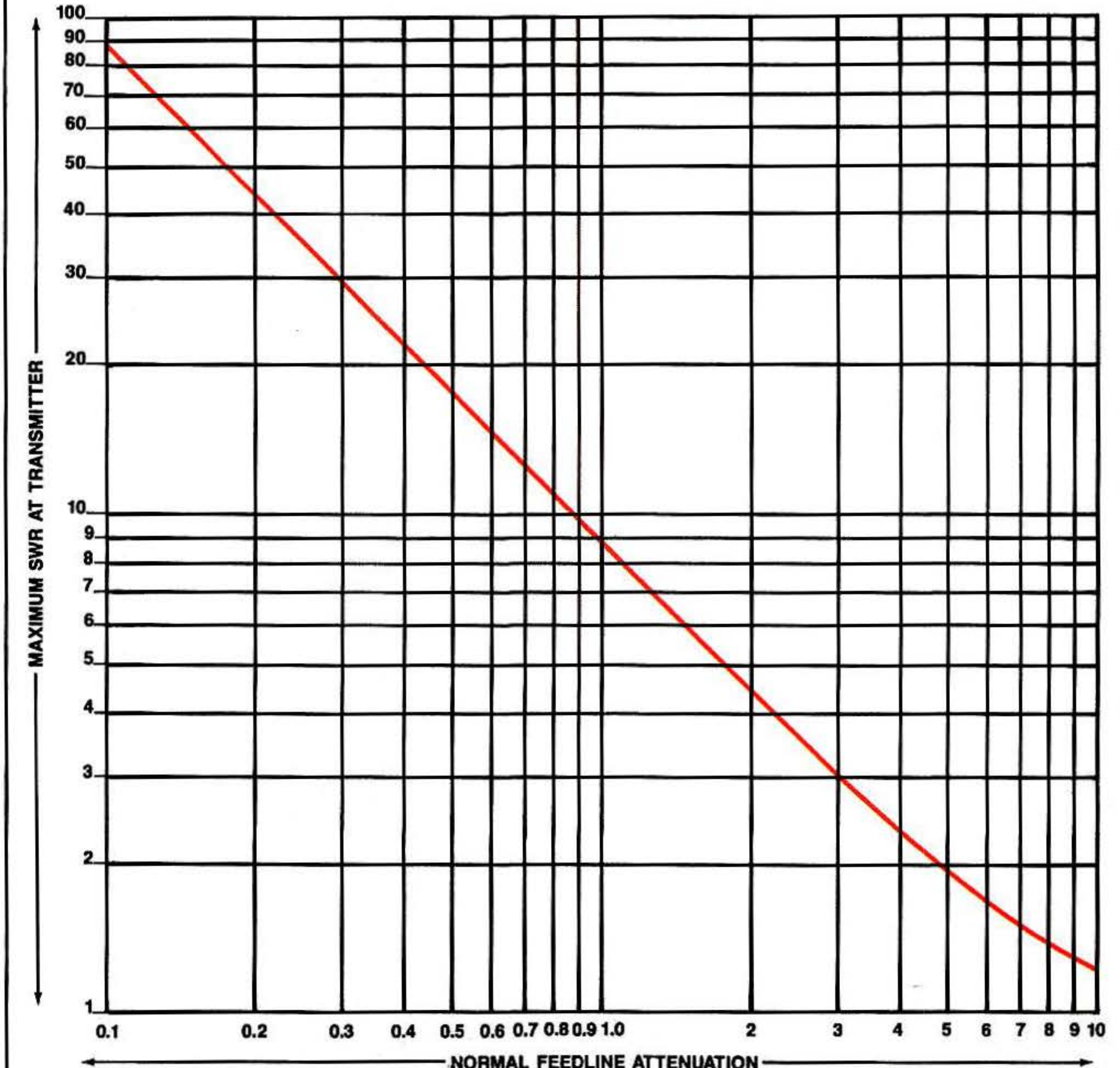


Figure 8. This graph shows the maximum SWR that can be seen at the feedline input for feedline loss values of 0.1dB to 10dB. It also can be used to find the SWR at the antenna if SWR at the transmitter and the normal line loss figure are known. For example, if the normal line loss is 1.5dB and the SWR measured at the transmitter is 3, the SWR at the antenna is found by locating SWR (3) on the vertical scale and moving over to the intersection of the curve, then down to the horizontal scale to 3. Then move down the scale to 1.5dB (3 – 1.5) and then back up to the intersection of the curve and over once again to the vertical scale at approximately 5.85.

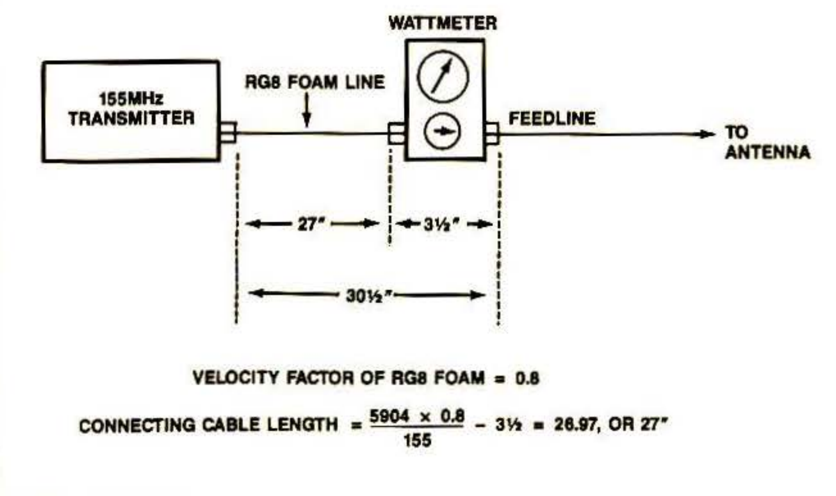


Figure 9. This diagram shows an example of how to determine the correct length of coaxial cable to use for a half-wavelength section when you tune a transmitter into a resonant line.

This phenomenon means that high feedline SWR can cause the feedline input to present a load impedance to the transmitter that differs greatly from the feedline's characteristic impedance. Some transmitters are equipped with an output matching network that provides a *conjugate match* to a fairly wide range of impedances. Other transmitters are more limited.

The best policy is to correct any feedline or antenna defects that cause high SWR. But if you must tune a transmitter into a resonant feedline, *use a ½-wavelength feedline to connect the in-line wattmeter.* When you measure the ½-wavelength section, be sure to include the length of feedline within the in-line wattmeter. (See Figure 9 above.)

If you use a length other than a ½-wavelength to connect the in-line wattmeter, the transmitter loading may change dramatically when the wattmeter and connecting line are removed. Imagine what would happen if a ¼-wavelength of connecting feedline accidentally were used!

Use the following equation to calculate a ½-wavelength of feedline:

Test cable in inches

$$= [(5904V/F) - L]$$

where

V = velocity factor of line
F = frequency in MHz
L = length of wattmeter line in inches.

Base station performance testing

This article deals with base station feedline and antenna performance testing. Because mobile and base station feedlines are similar, the techniques described also apply to mobile feedlines.

Although not every possible test procedure is presented, those of greatest interest to the land mobile technician are described, along with information about how to analyze the results.

Related articles appear in previous issues:

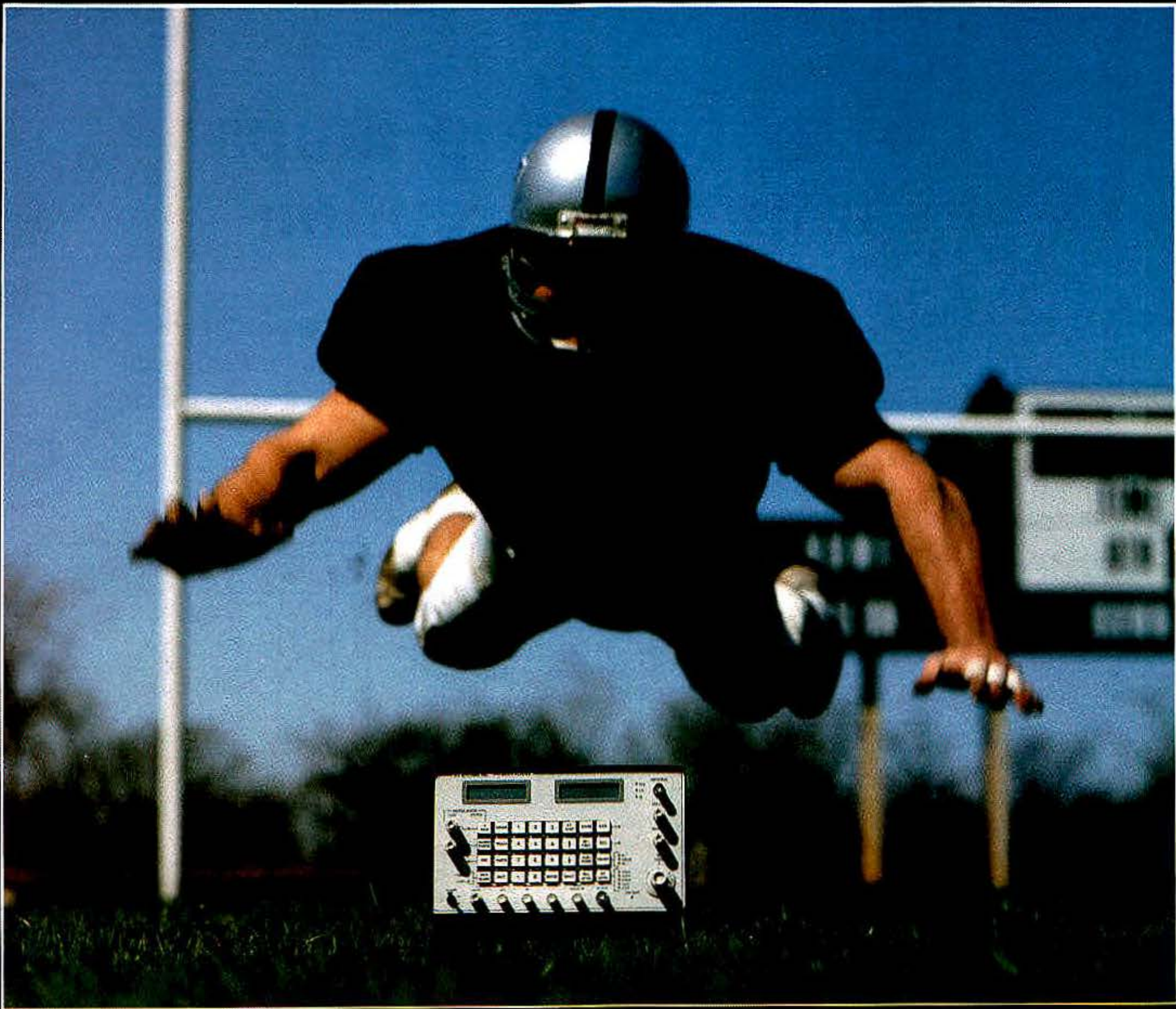
"Performance Testing For Base Transmitters" appears in the January 1988 issue.

"Performance Testing For Base Receivers" appears in the November 1988 issue.

A fourth article, "Performance Testing For Base Remote Controls," will appear next month.

Reference

Smith, Phillip H., *Electronic Applications of the Smith Chart*, McGraw-Hill Book Company, New York, 1969.



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Why towertop amps improve reception

Low-noise towertop amplifiers boost reception a lot for some systems, less for others. Simple calculations predict how much an amplifier would improve your reception. Feedline loss and site noise are important factors.

By Ernest N. Mann

How to achieve the highest possible receiving sensitivity is no secret: Amplify the radio frequency (RF) signal at the antenna, where the signal-to-noise ratio (SNR) is maximum.

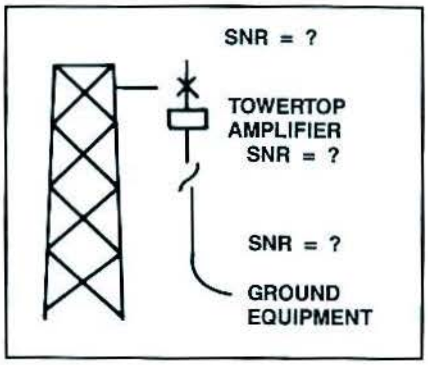

Figure 1. Important signal and noise locations.

The highest possible receiving sensitivity offers an obvious advantage, especially with systems that use portable transceivers. The more sensitive the receiver, the less transmitter power it takes to reach the base station. Portables usually have less transmitter power and poorer antenna efficiency than control stations or mobile units, so with improved base station receiver sensitivity, portables can be used more effectively. Communication with low-powered mobiles is improved, too.

Mann is a communications engineer at Central Maine Power, Augusta, ME. His book, *An Introduction to RF Systems: Written for the Two-Way Radio Industry*, is published by Mannbros Technologies, P.O. Box 2066, Augusta, ME 04330; 207-487-3751.

Placed as close as possible to the antenna, a low-noise amplifier improves the SNR at the receiver from what it would be without the towertop amplification. This is because it amplifies the received signal before feedline loss attenuates it. The amount of improvement depends upon the amplifier's gain and noise figure, as well as feedline loss and ambient noise at a given site. You can find some of these characteristics in manufacturers' specifications, and calculate or estimate the others to help you decide whether to use an amplifier.

You can decide whether to use an amplifier by comparing *system* noise figures with and without an amplifier to reveal how much improvement it may offer. The system noise figure is the difference between the SNR at the antenna to the SNR at the receiver input. The system noise figure always improves when a towertop amplifier is implemented properly, assuming all other system characteristics are unchanged. Models presented below allow for the receiver noise effects, incorporating them into the analysis to determine *effective* sensitivity improvement.

Typical system

Use the system configuration shown in Figure 1 at the left to calculate system noise figures with and without an amplifier. Feedline connecting the antenna to the amplifier usually is so short that loss is negligible, so consider signal and noise values at the antenna output and the amplifier input to be equal.

The feedline may terminate at a receiver or some other initial signal processing component, such as a preselector in a receiver multicoupler. In the example, "receiver input" will define the signal processing component at ground level. Therefore, consider signal and noise values at the receiver input to be equal to those present at the bottom end of the feedline.

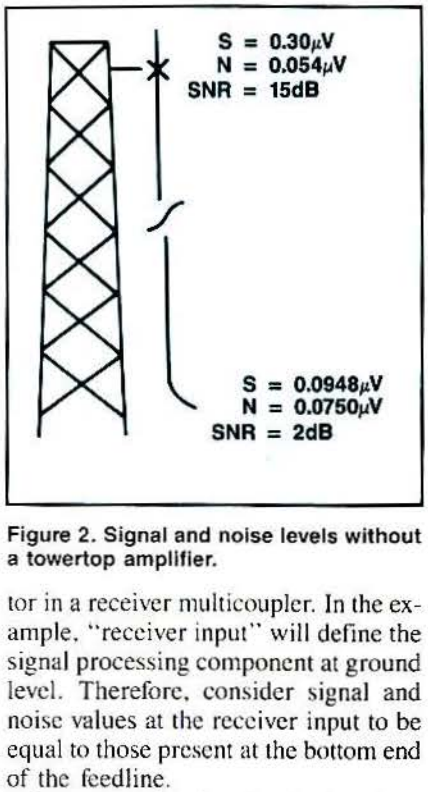

Figure 2. Signal and noise levels without a towertop amplifier.

Important signal and noise locations in a typical system are:

- antenna output (towertop amplifier input).
- amplifier output.
- receiver input (end of the feedline).

'Without amplifier' calculations

Your first set of calculations reveals the system noise figure (difference in SNR) without a towertop amplifier. Feedline loss does not change, so its calculation need only be done once. (See Figure 2 above.)

(1) *Feedline loss*—On the manufactur-

er's loss table, look up the type of hardline cable your system uses. The table shows loss in decibels per foot. Multiply the loss in decibels per foot by the length of feedline between your system's receiver and the top of the tower. The result is feedline loss in decibels. In the example, feedline loss is assumed to be 10dB. A 10dB loss figure may be quite high, but it is effective in showing how system noise figures differ between installations with and without a towertop amplifier.

Feedline loss affects system signal ratios (the ratio of signal at the antenna output or amplifier output to the the signal at the receiver input) and noise ratios (the ratio of the noise at the antenna output or amplifier output to the noise at the receiver input), so feedline loss affects receiver sensitivity for this example.

(2) *SNR, antenna output*—The system designer sets a minimum acceptable signal voltage expected at the antenna for the desired audio quality output at the receiver. In the examples that follow, a minimum level is chosen; this level delivers the desired audio quality output only when a towertop amplifier is used. The minimum acceptable signal voltage usually ranges from $0.3\mu V$ to $4\mu V$. The chosen level depends on the site's thermal noise characteristics and the system noise figure. Use the value you may find in the station records or estimate a new value that appears practical. For the example, the minimum desired signal voltage is $0.3\mu V$, a satisfactory level for rural systems with low system noise figures.

Thermal noise voltage at the antenna is proportionate to absolute site noise temperature and is independent of frequency when absolute bandwidth and feedline input impedance are constant. Use Equation 1 to calculate the reference site noise voltage V_n. Equation 1 is derived from the concept of noise power transfer from a source resistance (antenna) to a matched load (feedline).

$$V_n = \sqrt{kTBR} \qquad (1)$$

where

k = Boltzmann's constant

$= 1.38 \times 10^{-23}$ joules per °K

T = ambient site temperature (290°K or 63°F)

B = effective system bandwidth
R = load impedance

Assuming an ambient site temperature of 290°K (63°F), a 15kHz receiver IF bandwidth and a 50Ω feedline,

$$V_n = \sqrt{(1.38 \times 10^{-23})(290)(15kHz)(50\Omega)}$$

$$= 0.054\mu V$$

Therefore, the SNR at the antenna is $20\log 0.3\mu V/0.054\mu V$.

Equation 2 converts the voltage ratio to a decibel value:

$$20\log S/N = \text{(decibels)} \qquad (2)$$

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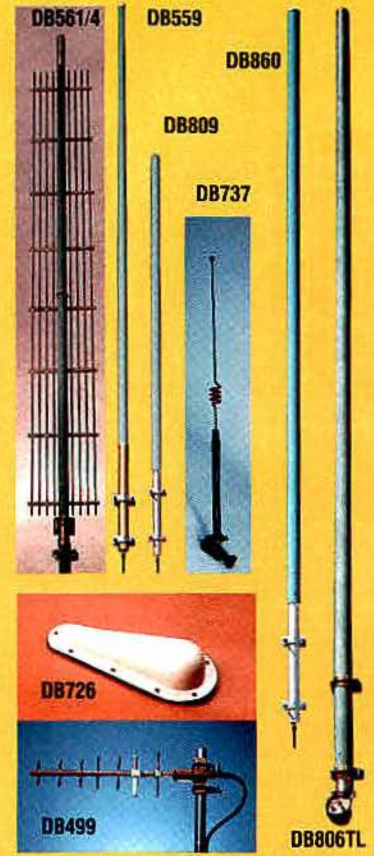

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In the example:

$$20\log 0.3\mu V/0.054\mu V$$

$$= 15dB$$

Feedline loss

Under these conditions: low site noise, 10dB feedline loss and no tower-top amplifier, the SNR at the antenna is degraded by feedline loss, so SNR at the receiver input is less.

First, the signal is attenuated:

$$20\log(V_1/V_2) = \text{(decibels)} \qquad (3)$$

If V_1 is less than V_2, the decibel value will be negative, implying attenuation.

In the example, the $0.3\mu V$ signal is attenuated by 10dB:

$$-10dB = 20\log x/0.3\mu V$$

$$x = \text{antilog}(-0.5)\times 0.3(10^{-6})V$$

$$= 9.48(10^{-8})V$$

$$= 0.0948\mu V$$

Similarly, feedline loss attenuates antenna noise voltage 10dB. If the resulting noise voltage at the end of the feedline is several decibels less than the receiver input's inherent noise, the feedline noise voltage is insignificant. Usually, without the amplifier, the feedline noise voltage is less than the receiver input's inherent noise, especially if the ambient site-noise level is low. The example uses a relatively low site-noise level involving only thermal noise generated from the earth's surface, as indicated by an antenna temperature of 290°K (63°F).

Receiver noise voltage

(4) *Receiver input noise*—Thermal noise from the antenna and noise from the system noise figure affect the receiver RF input's *effective* noise value (the equivalent amount of RF noise from site noise processed by the receiver and noise generated by the receiver itself). For most receivers, the RF noise value of the receiver alone is approximately 0.075μVrms, a voltage 10dB below a $0.25\mu V$ receivers' SINAD sensitivity specification. The 0.075μVrms value is an estimate that is a function of several complex variables, and one that is quite representative of a typical receiver.

The $0.054\mu V$ antenna noise voltage, after being reduced by the 10dB of feedline loss, becomes insignificant with respect to the receiver's own noise.

Therefore, calculate the receiver input SNR with the feedline-attenuated signal voltage, $0.0948\mu V$, and the receiver noise, 0.075μVrms, using Equation 2.

$$20\log 0.0948\mu V/0.075\mu Vrms = 2dB$$

It is apparent that an RF SNR of 2dB certainly would not be acceptable to produce intelligible audio, considering that a 10dB SNR at the receiver input will provide a 12dB SINAD output. Similarly, the proposed $0.3\mu V$ miminum acceptable signal voltage, chosen for the example, is anything but acceptable.

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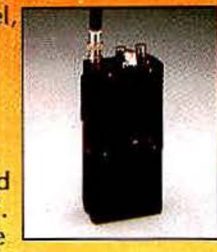

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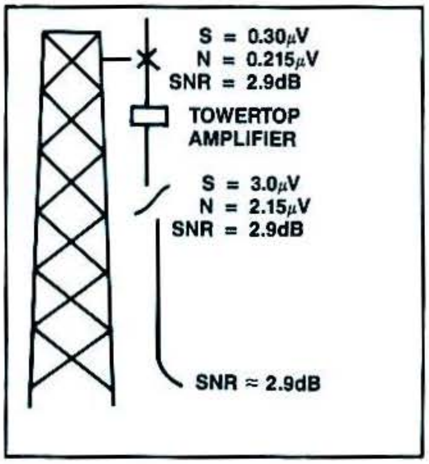

Figure 5. Signal and noise levels at a high-noise site, without an amplifier.

ceiver sensitivities. This scenario is illustrated in Figure 5.

In the example, the received signal level is $0.3\mu V$ and feedline loss is 10dB, so the signal delivered to the receiver input, as derived from Equation 3, can be calculated:

How much improvement can you expect?

Towertop amplifiers improve reception for some systems more than they do for others.

The greatest reception improvement can be expected when towertop amplifiers are installed at a site with a relatively low noise level and/or a relatively high feedline loss.

Low site noise

First, for systems with low site-noise levels, feedline loss degrades the S/N level present at the antenna to a lower S/N level at the receiver. The feedline attenuates the antenna noise below the receiver input's own noise level. Instead of the antenna noise limiting weak-signal reception, the receiver's inherent noise limits weak-signal reception.

The weak signal is present on the feedline but is masked by the receiver's own noise.

A towertop amplifier boosts the signal and noise picked up by the antenna to higher levels before sending them down the feedline. Although the feedline still attenuates both, the signal and noise remain at much higher levels than the receiver's inherent input noise when they arrive at the input. Weak signals are not masked as much by receiver input noise because a low-noise, high-gain device can offset receiver noise to some degree and reception improves.

High site noise

At sites with high noise levels, the noise delivered by the feedline without an amplifier comes closer to the receiver input noise level. Weak signals

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are masked not so much by receiver noise as by the site noise. The SNR at the antenna is less to begin with than it is at a site with low noise. An amplifier always offers some improvement at a site with high noise, but the difference is not as pronounced as it is at a site with low noise.

Mathematically speaking, this is because low system noise figures are not as critical when the input noise to the system is significantly larger than the reference noise of the signal processing components.

Second, the greater the feedline loss, the more it limits weak-signal reception. Because a towertop amplifier overcomes feedline loss, the improvement it delivers is more obvious in systems with larger losses.

Feedline loss and site-noise levels are the most important factors to consider in evaluating the receiver-sensitivity improvement a towertop amplifier may offer. You should calculate the loss and measure the noise before deciding whether to buy an amplifier. If you are going to purchase an amplifier regardless of feedline loss and noise level, you still should include these characteristics as part of your consideration of other equipment purchases.

Feedline losses and noise levels differ from site to site, so amplifier performance at your site will differ from the performance shown in the examples. Use calculations to predict the results to expect from using an amplifier at your site.

$$-10\text{dB} = 20\log x/0.3\mu\text{V}$$

$$x = \text{antilog}(-0.5) \times 0.3 \times 10^{-6}\text{V}$$

$$= 9.48 \times 10^{-8}\text{V}$$

$$= 0.0948\mu\text{V}$$

Next, calculate the noise level from the antenna at ground level. The feedline attenuation value of 10dB and a site-noise value at the antenna of 0.215μV results in 0.067μV antenna noise at the feedline (ground level). The antenna noise at the end of the feedline must be added to the receiver input RF noise because they are comparable. It would not hurt to always incorporate the effects of both site noise and internal receiver noise to find a composite noise value.

Remember a 3dB to 4dB difference dictates that only the larger level be used in the equation defining receiver input SNR. When this is the case, an approximate error of 0.5dB could result. Larger errors would occur if levels were within 1dB or 2dB and both noise com-

	RECEIVER INPUT SIGNAL TO NOISE RATIO (dB) LOW SITE NOISE	HIGH SITE NOISE
With amplifier	13	2.9
Without amplifier	2	−0.4
SNR improvement	11	3.5

Table 1. Improvement delivered by a towertop amplifier in low site-noise and high site-noise environments (for conditions set out in examples).

ponents were not incorporated into the analysis.

To add two rms noise components, use the equation:

$$\sqrt{(V_1)^2 + (V_2)^2} = \text{Vrms} \qquad (4)$$

Using values from the example,

$$\sqrt{(0.067\mu V)^2 + (0.075\mu V)^2} = 0.1\mu \text{Vrms}$$

Use the combined antenna and receiver input noise level, 0.1μVrms, as the noise value to compare with the received signal in computing the receiver input SNR without the towertop amplifier.

At the high-noise site, without the towertop amplifier, the SNR at the receiver is derived using Equation 2 and the levels just calculated:

$$SNR = 20\log 0.0948\mu V/0.1\mu \text{Vrms}$$

$$= -0.4\text{dB}$$

A previous example showed that, with a towertop amplifier in place under high site-noise conditions, the SNR is 2.9dB. The improvement is the difference:

$$2.9\text{dB} - (-0.4\text{dB}) = 3.5\text{dB}$$

High/low site-noise comparison

You will find it useful to compare the SNR improvement for both the low and high site-noise cases. (See Figures 2 through 5 and Table 1 at the left.)

Comparison table

Table 1 compares the improvement delivered by a towertop amplifier under the conditions spelled out in the examples for low site-noise and high site-noise environments.

SNR improvement is much greater in a low site-noise environment. That is why some sites show a great improvement in signal quality and range when a towertop amplifier is added and others show, at best, a modest improvement.


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Telephone technology solves radio simulcast problem

Innovative use of telephone conference-call technology brings a form of simulcast operation to the Fresno County Sheriff's two-way radio system. Certain costs associated with single-frequency simulcast are avoided.

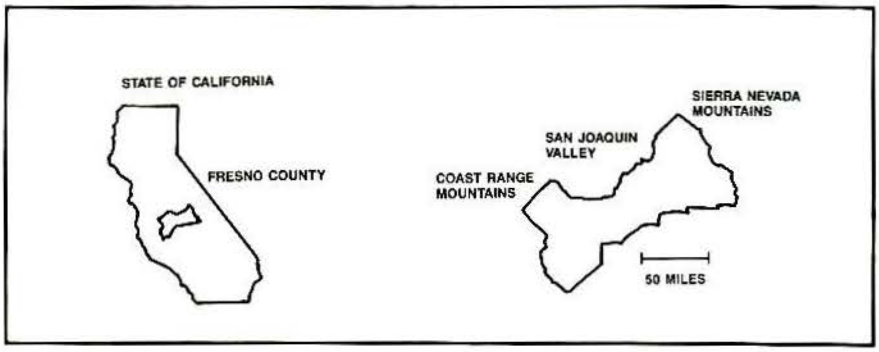


Figure 1. Fresno County lies in central California. Its terrain includes mountains to the east and west, with a broad valley floor between them.

By John Downing

When coverage and capacity requirements outstripped what Fresno County's 1950s-vintage VHF lowband two-way radio system could deliver, the search began for good advice and economical solutions. Thorough investigation of alternatives led to the development of a dual-frequency simulcast system with a sophisticated audio control derived from telephone teleconferencing technology.

The problem

Not only was the lowband radio system's coverage inadequate by 1979, the system was plagued by:

- skip interference
- poor performance from portable transceivers.
- big (50-inch) disguised mobile antennas that hampered undercover operations, and that did not work well in crossband mode because of the special tuning stub required to match the shortened antenna. Crossband communication requirements grew as more than 80% of the local law enforcement agencies and the country's local government and public works department moved their operations to VHF highband.
- the use of mid (33MHz to 42MHz) and high (42MHz to 50MHz) splits configured for repeater operation, rendering simplex (talkaround) operation impossible.
- the migration of neighboring agencies to VHF highband, making same-frequency communication between agencies impossible.
- increasingly heavy traffic. The original channels, which originally supported only the patrol division, later were pressed into service to support special units of detectives, vice, investigations, intelligence and narcotics squads, as well as communications from nearby communities with mutual aid agreements with the department.

Covering Fresno County is not easy. Located in San Joaquin Valley in central California, the county encompasses 6,000 square miles. Its geography includes Coast Range mountains at 5,000 feet, a wide valley floor and Sierra Nevada Range mountains at 13,000 feet. No one transmitter site can cover the county reliably. (See Figure 1 at the left.)

Single-frequency option

The first consultant hired to solve the problem recommended replacing the VHF lowband system with a single-frequency VHF highband simulcast system. Simulcast refers to *simul*taneous broad*cast*, the transmission of the same message at the same time by multiple transmitters. The transmitters may be on the same frequency or different frequencies. The transmitters are positioned to offer coverage superior to the coverage a single transmitter would deliver.

The cost would have been high:

First, the cost of a new radio system, including mobiles and portables.

Second, the existing microwave system would have to be restructured to provide the necessary transmitter control.

Third, the new transmitters would have to be fitted with expensive, high-stability oscillators.

Fourth, ongoing costs, including maintenance and additional employees to sustain the system.

The price tag for one channel was quoted at $600,000, and the sheriff had requested two channels. The single-frequency simulcast system was ruled out.

The next recommendation, from two consultants, including the original con-

Downing is a telecommunications engineer with Fresno County in California.

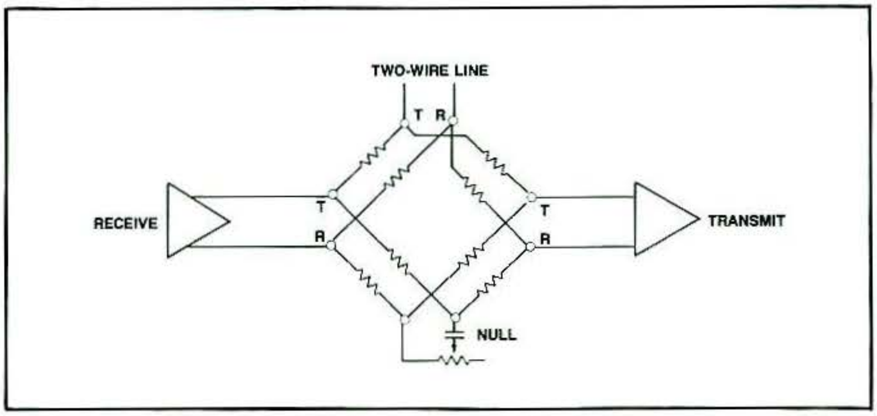


Figure 2. Electronic circuitry used by some of the more basic conference call units is nothing more than a resistive audio bridge.

sultant, advised the use of a multifrequency simulcast system. Multifrequency simulcast does not require absolute control of audio and radio frequencies, and voice and subaudible tone control signal phasing, the way single-frequency simulcast does.

The greatest single disadvantage, as far as the county was concerned, was the need to ask individual radio users to switch between channels. With single-frequency simulcast, the radio remains on one channel. But as it turned out, the need to switch from one channel to another never was a problem.

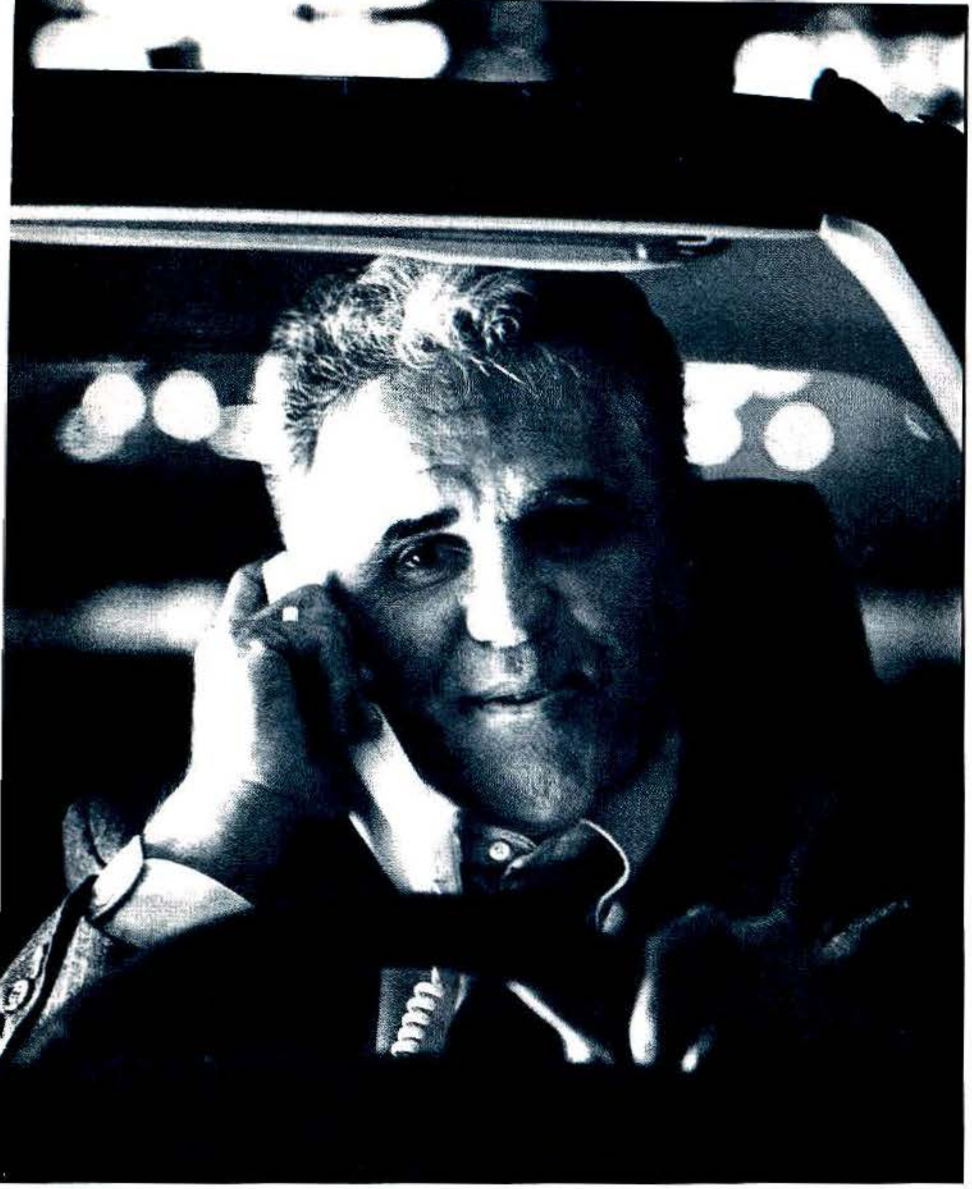
Multifrequency simulcast offered several other advantages:

(1) *Frequency reuse*—With the San Joaquin Valley's diverse topography, some co-channel users as far as 120 miles away had to be protected. The protection requirement stems from the extraordinary radio coverage rendered by a transmitter on a mountain, for example, 7,000 feet above the valley floor.

With a single-frequency simulcast system, a frequency would have to be found that protects all co-channel users from every transmitter site in the county—a nearly impossible requirement.

But with multifrequency simulcast, frequencies can be distributed according to transmitter site and co-channel protection requirements. A frequency unusable in the northern part of the county might be usable in the southern part, for example.

(2) *Reliability*—Many single-frequency simulcast systems are designed with the control of received signal distortion in areas where transmitter coverage areas overlap. When one transmitter fails, the resulting



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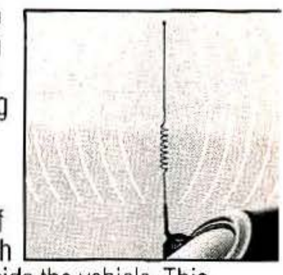

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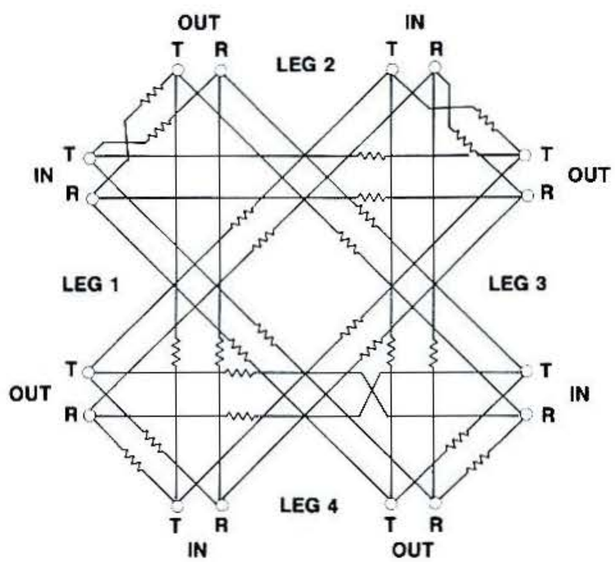


Figure 3. Despite delicate balancing requirements and high insertion loss, resistive bridges are used commonly in audio circuits for as many as four ports and with losses as high as 15dB.

overlap from the remaining transmitters may produce unacceptable distortion in some areas.

With the multifrequency system, each coverage area stands alone. No transmitter depends on the proper operation of another to deliver an acceptable signal in its coverage area.

(3) *Tactical reconfiguration*—The multifrequency simulcast can be disconnected to give the department access to separate radio channels for special emergency or tactical operations.

Audio challenge

The challenge for the system designer was how to mix the dispatcher's talk-out audio for distribution to multiple transmitters and how to mix the mobile receive audio and redistribute it to the multiple transmitters. All this audio distribution is necessary to allow users on one frequency to hear both sides of a conversation that may be occurring on another channel.

Another requirement imposed by the

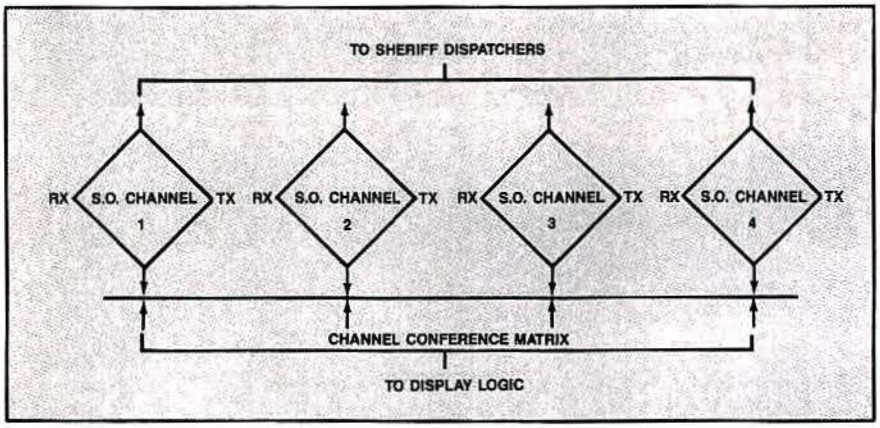


Figure 4. The radio channel conferencing system connects each 4-wire circuit to the bridge. An unused bridge port connects with a matrix. Under the dispatcher's control, any of the four bridges may be connected together.

department was that each of the four geographic patrol areas be served by a discrete radio channel. The discrete channels had to be configured so they could be combined electrically or be kept separate from any other channel.

During periods with high dispatching activity, as many as four dispatchers would be able to dispatch their respective radio channel. As channel activity subsided, the number of dispatchers could be reduced to three or two, with patrol areas combined accordingly. Overnight, all four channels would be combined under one dispatcher.

With all channels combined, any deputy on any channel would be able to speak with any other deputy on any other channel, and the dispatcher.

The first efforts at distributing the audio for various multifrequency simulcast configurations involved the use of the "simul-select" features on the control consoles. The feature routes audio through communications consoles to different radio channels.

Each of the consoles tested used voice-operated transmission (vox). Because of the nature of the vox, the first word of a transmission was lost before all the transmitters activated. If the operator hesitated between words, the transmitters would unkey, then rekey with the next phrase, losing the first word once again.

Units whose modulation was weak or whose operators were soft-spoken would not activate the vox circuitry at all. After expending much time and effort, the department concluded that the "simul-select" approach did not fit the sheriff's application.

The right answer turned out to be quite simple. Most new telephone systems offer call conferencing. With this feature, a caller can connect with one phone number, then add other numbers to the conversation. Some equipment provides for as many as 30 circuits to be connected in a conference call.

The electronic circuitry used by some of the more basic units is nothing more than a resistive audio bridge. (See Figure 2 on page 66.)

Audio entering the receive leg from the left is split electrically. A portion of the audio is routed to the 2-wire line, then continues clockwise to the transmitter. But a separate audio path from the receiver routes counter-clockwise through a compensating or "null" network and also arrives at the transmitter port 180° out of phase.

The net result is that receive audio is passed to the 2-wire line, but not to the transmitter. Audio entering the 2-wire line is split and routed between the transmitter and receiver. But because the receiver side is isolated by an amplifier, audio cannot follow this route, and it does not appear in the receiver side.

The remaining audio appears at the transmitter port and is routed to further amplification and processing. Resistive hybrids work well, but the biggest disadvantage of the resistive bridge is that it must be balanced perfectly to maintain high isolation. Moreover, it suffers from high insertion loss. Even with these disadvantages, resistive bridges are used commonly in audio circuits. Bridges with as many as four ports and losses as high as 15dB are common. (See Figure 3 on page 68.)

Active bridge

With today's modern units, high insertion losses and requirements for perfect balance for maximum isolation have been overcome. For example, the Tellabs 4446 active bridge module was designed specifically for conference call applications. It offers selectable insertion losses of 0dB, −16dB or −23dB. With the active output amplifier, input or output terminations no longer are critical. In fact, it is unecessary to terminate unused ports. Lack of termination does not upset the bridge balance. Transbridge loss (input to output) remains at 90dB.

Using the Tellabs 4446 equipment as the heart of the system, the department designed a radio channel conferencing system. Because all the radio channels were controlled remotely through the county's microwave system, all transmission and reception to and from the sites was carried by a 4-wire circuit, which matched exactly the requirements of the conferencing units. (See Figure 4 on page 70.)

With each 4-wire radio channel connected to the bridge, an unused port was brought out of the bridge and run to a matrix. The matrix, controlled by the dispatcher, allows any of the four bridges to be connected together. The result: In a two-channel conference mode, audio appearing on one radio

channel is routed to the dispatcher *and* to the second radio channel. In a three-channel conference mode, audio is routed to the dispatcher *and* to the second *and* third channels. The four-channel confererence mode is attained similarly.

So simple was the installation, once the equipment was found and the design completed, that the radio channels were not even taken out of service during installation.

Each radio patrol area was given a number code. Now it is possible when required to meet emergency, staffing or technical demands to rearrange the communication system for one to four dispatchers, each transmitting to the dispatcher's own area and one dispatcher transmitting simultaneously to all four patrol areas. It also is possible to reconfigure for any intermediate combination.

Because the department refers to each patrol area by color code as an operational aid to the dispatcher, a display panel was built to indicate with colored lights the conferencing unit's configuration.

The logic and control equipment is prototype, but it has worked exceptionally well with the commercial equipment. Its users like the results. From an operational perspective, the deputy in the field no longer has to switch from channel to channel as dispatcher shifts change. The deputy remains on one radio channel that has been optimized for the best coverage of the patrol area. As dispatching workloads change, patrol areas can be added together or split apart as necessary to balance the workload, with the touch of a button.

Each radio patrol area was given a number code.

Sophisticated electronics

The radio channel conferencing technique was developed using sophisticated, state-of-the-art electronics. Like the single-frequency simulcast, it required considerable support equipment in the form of microwave, satellite voting receivers and multiple transmitter sites.

Also like simulcast, it is technically complex. It offers the advantage of not requiring constant attention that a single-frequency simulcast system requires. It allows the user the flexibility to restructure the system.

The county government is pleased with the performance of the channel conferencing system—advantages far outweigh disadvantages. Faced with upgrading its communications system, and faced with the potentially high cost of single-frequency simulcast, the county found the channel conferencing network a practical alternative.

Telocator Spring International Convention

Telocator launches its first international convention May 3-5 at the Orange County Convention/Civic Center in Orlando, FL. Telocator is a trade association of mobile telephone and radiopaging system operators. A telephone call to 202-467-4781 will bring you registration materials and information from the association's headquarters in Washington, DC.

For help in making your plans, refer to the boxed information for show times and "Session Guide" on page 78.

The theme, "The Worldwide Reach of Mobile Communications," is reflected by a session track focused on opportunities for American mobile communications in foreign markets. Richard Gephardt (D-MO), a leading congressional proponent of a strong American trade posture, will keynote the international track and then moderate a panel discussion on market opportunities arising from elimination of all internal European trade barriers in 1992.

The overall keynote convention address will be delivered by Richard Kirby, director of the ITU's International Radio Consultative Committee (CCIR) in Geneva.

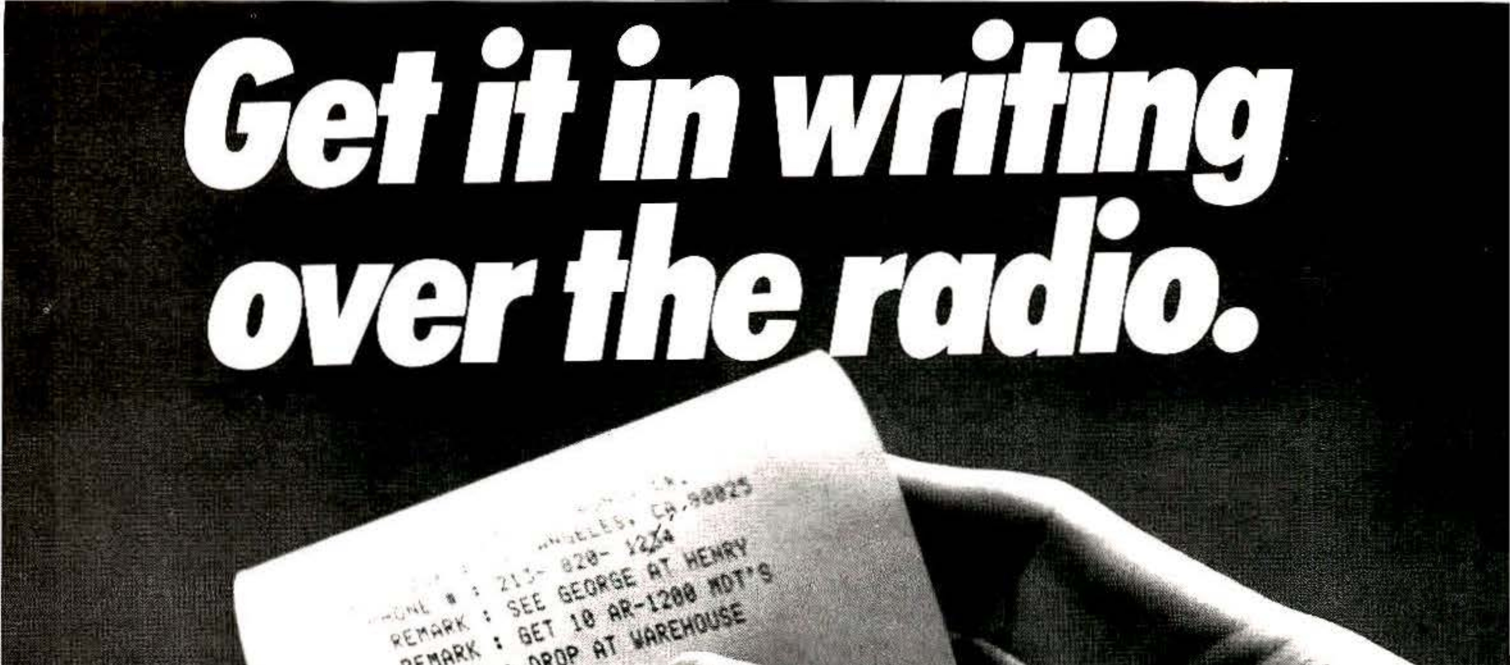
Two special sessions will feature important topics in mobile communications: state efforts in interconnection and cellular RSAs.

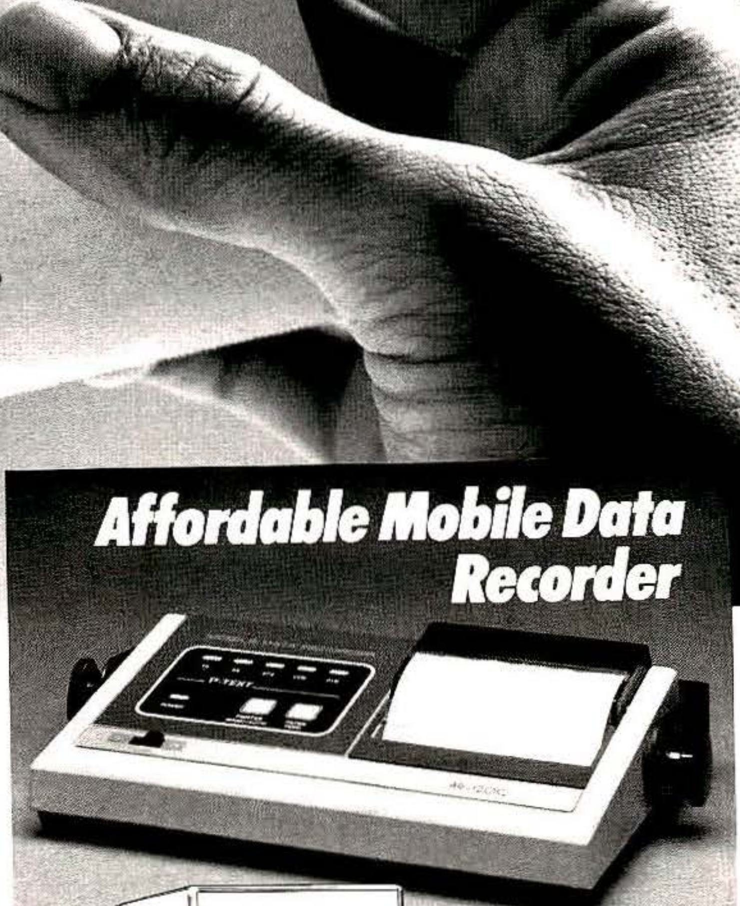
The closing luncheon is set for Friday, May 5, at 2 p.m.; the identity of the keynote speaker was not available at press time.

Event: Telocator Spring International Convention
Dates: May 3-5
Location: Orange County Convention/Civic Center
City: Orlando, FL
Number of Exhibitors: 100
Projected Attendance: 2,000
Exhibit Hours: Wednesday, May 3, noon to 5 p.m.
Thursday, May 4, noon to 6 p.m.
Friday, May 5, 9 a.m. to noon
Seminar Schedule: Wednesday, May 3, 9 a.m. to noon
Thursday, May 4, 8 a.m. to noon
Friday, May 5, 8 a.m. to 2 p.m.
Registration/Hotel Information: 202-467-4781

Session Guide

DAY	TIME	Orange County Center ROOM	TOPIC
Wednesday, May 3	9-9:30 a.m.	12	Association Business— State of the Association
	9:30-10:30 a.m.	12	Featured speaker: Richard Kirby, director of the CCIR
	10:45-noon	11A	State Efforts in Interconnection
		12	RSA Update
Thursday, May 4	8-9 a.m.	10A	Meet the FCC
		10B	Digital Cordles Telephones: The Prospects
	9-10:30 a.m.	11A	Pan European Paging
		11B	Financial Strategies of Mergers
		11C	Building Repeat Business Through Service Excellence
	10:45 a.m.-noon	11A	Applying Foreign Mobilcom Practices to the U.S.
		11B	Build vs. Buy
		11C	Churn
Friday, May 5	8-9 a.m.	10A	Washington Update
	9-10:30 a.m.	12	International Keynote Session
	10:45 a.m.-noon	11A	Taking U.S. Telecommunications Expertise Abroad
		11B	Optimizing an Acquisition: Tax and Depreciation Issues
		11C	Quality of Service: New Applications
	12:15-2 p.m.	12	Farewell Luncheon and Keynote Address





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Circle (69) on Fast Fact Card

Repeater mod combines tone and digital squelch

Overlaying CTCSS tone boards on a digital coded squelch repeater system combines the two squelch control systems and lets the customer use both kinds of radios at any time.

By Rod Wheeler

Hasn't everyone in the two-way radio business faced a challenge with digitally coded squelch (DCS) systems? Even though not all radios offer DCS as a squelch option, the lack of the squelch option might be a blessing in disguise.

A little more than a year ago, a customer asked to buy portable transceivers to add to a system with other portables, equipped with DCS, already in service. He wanted 20 radios.

Wheeler owns The Radio Shop in Diamond Bar; works as an RF technician at Disneyland in Anaheim; and serves as chief engineer of KSAK-FM in Walnut, CA.

The customer's company has its own repeater. The system's portables have four different selectable squelch codes on the same RF channel. *One* DCS code is hard enough, but *four?*

The company's operation is divided into four areas—security, maintenance, custodial and grounds—each with a separate code on the same RF channel and each with the capability of simplex operation (talkaround) on the repeater output frequency without a coded squelch.

The customer wanted to replace the current portables, which as new units sold for more than $2,000 each, with smaller, less expensive units. But only one of my suppliers offered units with DCS then, and none had the capacity for four codes.

You might think the solution would be to change the customer's repeater to operate with continuous tone-coded squelch system (CTCSS) and to do away with DCS. That would not work because the customer wanted to keep the older portables operating until they become too expensive to repair. And newer portables must communicate with the old portables on all four DCS codes.

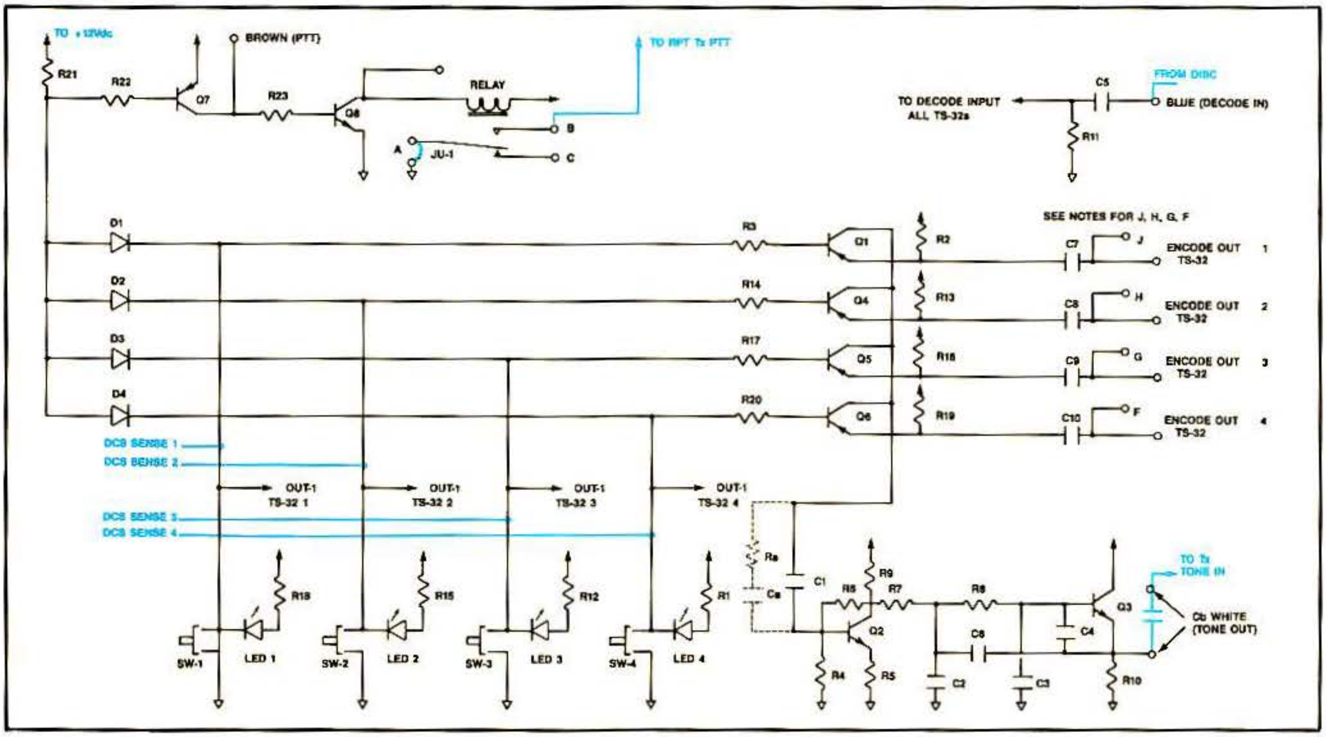
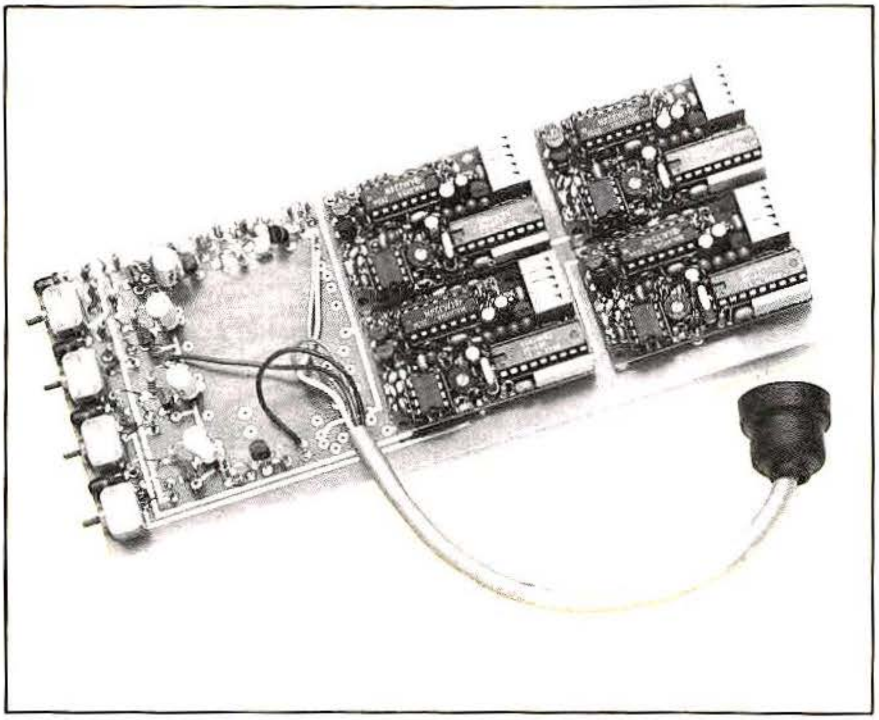


Figure 1. AP-1 carrier board schematic shows where to make the connections described in the text. On the TSU-32 units (not shown) AF output and AF input points are connected with the repeater's transmit and receive audio path.



Here is how the AP-1 carrier board looks with the hard wire connections made as diagrammed in Figure 1 and with the four TSU-32 tone boards installed.

If one system has some portables with DCS and others with CTCSS and all units must work at the same time, then the repeater must transmit *both* DCS codes and CTCSS tones at the same time. The repeater never *decodes* more than one code or tone at a time. All it must do is *encode* and transmit both types of codes simultaneously whenever the repeater is in use.

To accomplish this task, the Communications Specialists AP-1 carrier board (designed for use in a General Electric MASTR repeater) with four TSU-32 encoder-decoders is used. The board encodes and decodes CTCSS tones; connects with the customer's repeater input and output; filters tone for the repeater; and visually indicates DCS and CTCSS code operation.

Board installation

The AP-1 board is connected as shown in Figure 1 on page 80.

Normal 12Vdc is supplied to the

board. An audio highpass filter from one of the TSU-32 units is inserted into the audio lead between the repeater's receiver and transmitter to prevent received CTCSS tones from interfering with tones generated by the TSU-32 units.

AP-1 tone output connects to the transmitter's tone input. The AP-1's relay or Q8 controls the repeater transmitter through a connection to the repeater's push-to-talk (PTT) line. The repeater receiver's discriminator output is fed to the AP-1 board's decode input.

The system worked so well it was hard to believe.

Tones are selected as follows: Four points on the AP-1 are marked OUT 1 on each of the TSU-32 units. Each OUT 1 point serves two purposes.

(1) The point is the input from the repeater's DCS decoder output. When a DCS code is received, the corresponding OUT 1 is pulled low, activating the TSU-32 and causing it to transmit a CTCSS tone. The OUT 1 also keys the transmitter that already is generating its own DCS code. In this way, both the CTCSS tones and DCS codes are sent.

(2) When a CTCSS tone is received, the OUT 1 that corresponds to that tone is pulled to ground. That activates the RPT TX PTT switch, causing the transmitter to transmit and send a CTCSS tone. It also activates the repeater's internal DCS encoder, so both codes are sent.

Light emitting diodes (LEDs) on the AP-1 indicate which tones are in use. Push-buttons on the AP-1 provide an easy test function.

The system worked so well it was hard to believe. Now a word of caution: Use the higher CTCSS tones, beginning with 250.3Hz and working down if more than one tone is required. Communications Specialists can supply the TSU-32s for operation on any of the 38 standard tones at no extra cost by replacing the crystal, if requested. The combined tone level results in an RF carrier deviation greater than normally is used for tone signaling, about 1.25kHz, so set the voice modulation level so the deviation during voice communication does not exceed 5kHz.

How to avoid FCC violation notices

Interference to public safety communications draws FCC enforcement action fast. Investigation of spurious-emission interference and allegations of 'paper loading' on trunked systems are top priorities.

Self-inspection

The FCC private radio bureau suggests land mobile radio licensees regularly check:

- ☐ ***Frequency*—Verify that frequencies in use match the frequencies identified on the license. Adjust each transmitter's carrier frequency to be within the percentage of the assigned frequency shown in Section 90.213 of the rules.**
- ☐ ***Location*—Verify that base station, control station, wireline control points, mobile relay (repeater) and other fixed station locations match the locations shown on the license. Most common violation: Licensed geographic coordinates do not correspond with actual fixed station locations.**
- ☐ ***Antenna height*—Verify that the antenna height matches the height specified on the license. Most common violation: On a shared tower, the antenna is installed at a height that differs from the licensed height.**
- ☐ ***Transmitter power*—Measure the transmitter output power or calculate the effective radiated power at the antenna to be sure they do not exceed the power limit shown on the license.**
- ☐ ***Bandwidth*—Measure the transmitter's bandwidth and spurious emissions to verify that they do not exceed limits shown in Section 90.209 of the rules.**
- ☐ ***Qualified technicians*—Employ qualified technicians to carry out transmitter service and maintenance.**
- ☐ ***Identification*—Identify your station as spelled out in Section 90.425 of the rules.**
- ☐ ***Short transmissions*—Keep your communications as short as practicable.**
- ☐ ***Harmful interference*—To avoid harmful interference, take reasonable precautions, including monitoring the frequency for communications in progress before transmitting.**
- ☐ ***Reports*—Be sure your reports to the FCC on construction or loading as required by the rules or the terms of your authorization are accurate and filed on time.**

Licensees who regularly check these 10 items reduce their chances of receiving a rule violation notice from the FCC.

By Don Bishop
Editorial Director

One of the FCC's top objectives in regulating private land mobile radio communications is controlling interference. Interference control benefits all radio users: An interference-free channel offers better coverage, faster access and clearer communications.

The federal agency sometimes inspects land mobile radio systems for compliance with its rules to ensure noninterference with other users. Its current budget restricts such inspections mostly to responses from complaints received.

With FCC inspections at a minimum, the commission's Private Radio Bureau recommends licensees *inspect their own* stations. A list of items to inspect appears in a box at the left.

We talked with Jeff Young, an on-scene enforcement specialist who works in the FCC Field Operations Bureau's Investigations and Inspections branch, about the self-inspection program. He elaborated on the 10-point program:

• *Frequency*—"Off-frequency operation is not as common today as compared to 10 or 15 years ago," he said, "although it is still a fairly commonly cited violation. We consider it important because off-frequency operation is likely to cause interference to adjacent channels."

Young said the problem has eased because transmitters with oscillators compensated for temperature changes and controlled by frequency synthesizers—common features in many

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transmitters currently manufactured—are relatively stable.

Incorrect coordinates

• *Location*—Several causes may be at the root of a fixed station being operated at the "wrong" location, i.e., somewhere other than that specified in the station license.

"Often, the discrepancy stems from the license application," Young said. "The geographic coordinates specified by the applicant may be incorrect for the actual location where the applicant intends to build."

He said the FCC often finds out only when it responds to an interference complaint. Interference may result because the frequency coordinator generally selects the best frequency for minimum interference based on the application, but the licensee builds the station in another location where the frequency may not be favorable. "When that happens it must be straightened out," Young said.

Straightening out the interference may involve station modifications at the licensee's expense. So specifying the correct coordinates in the first place is the best policy. But if you were to find today that your licensed coordinates do not correspond with your station locations, a correction may involve only paperwork. *After* an interference complaint results in an FCC inspection, more expensive corrective action may be required.

"There may be hundreds or even thousands of stations built elsewhere than locations specified in their licenses," Young said. "Until they cause a problem, they are not likely to be discovered."

Shared towers

• *Antenna height*—Young said the FCC quite often finds antennas mounted at heights that differ from heights listed in station licenses, "often where a lot of antennas share a common supporting structure."

A possible reason is that tower space availability changes between the time the license application is filed and the time the license is granted. The site manager assigns another space, but the licensee does not request a modified license from the FCC.

• *Transmitter power*—"Although a licensee who uses more power than the license authorizes may cause interference, Young said, "overpower is less likely to cause interference than an antenna installed higher than authorized or a station built somewhere other than where the license specifies."

He said higher power increases range, but it is not a linear relationship: twice the power delivers much less than twice the range. "But we hold licensees to their authorized power and we will penalize them and fine them if the power they use exceeds the licensed power," he warned. Overpowered operation can create a variety of problems for other co-located radio systems or audio devices.

"Location, antenna height and power

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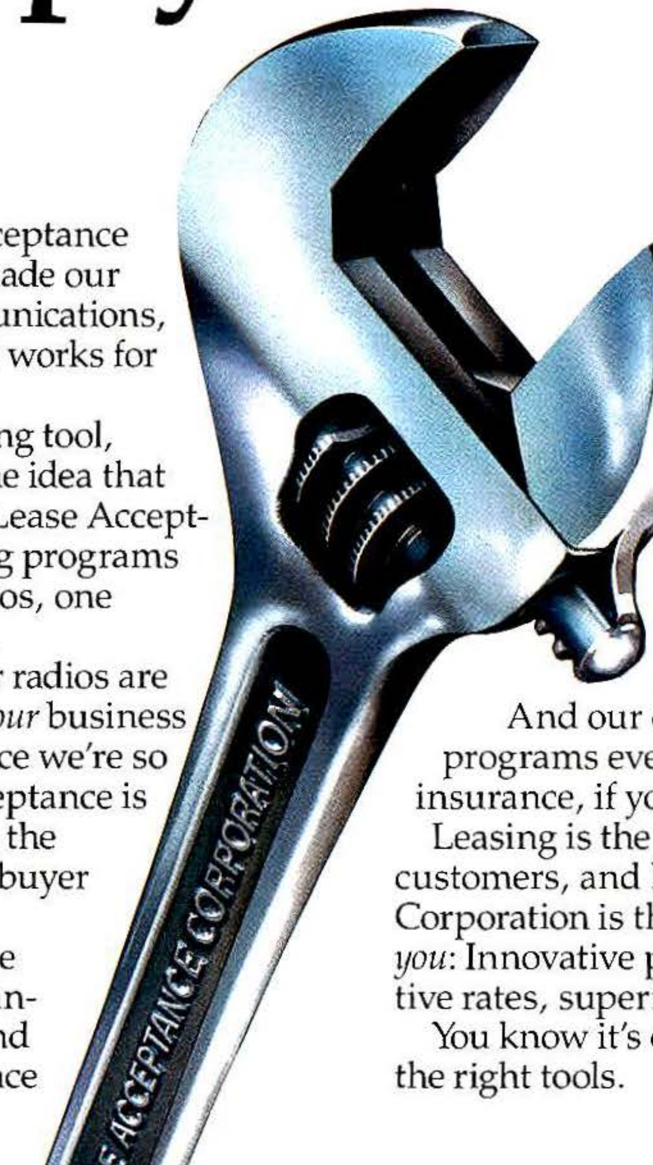

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are the main factors that frequency coordinators use in recommending the best frequency for the FCC to assign for minimum interference," Young said. "If what is built differs from what has been authorized, it is more likely that interference will result."

Spurious emissions

• *Bandwidth*—The most complex technical problem the regulatory agency faces in resolving land mobile radio interference complaints involves spurious emissions, also called *spurs*.

One form of spur is signals the transmitter emits on frequencies other than the authorized carrier frequency and outside the bandwidth authorized for modulation products.

"If a transmitter spur falls on someone else's channel, the offender will not necessarily know what is causing the problem," Young said. Checking the transmitter with test equipment, such as a spectrum analyzer, can reveal spurs before the FCC comes calling in response to an interference complaint.

"We are called upon to resolve spurious emission interference more than perhaps any other kind," Young said, "because it requires the most technical expertise. Modulation on the spur may be unintelligible and the victim may be unable to identify the source."

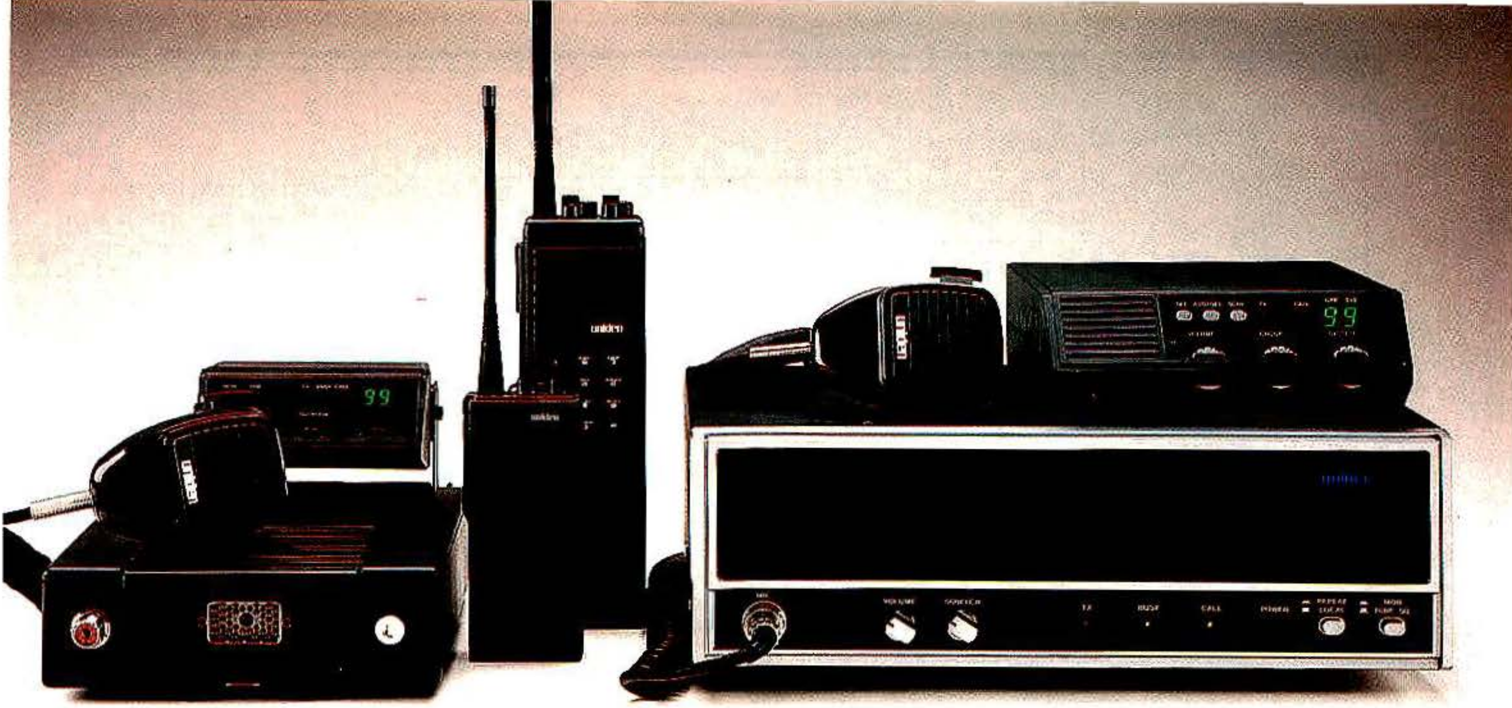
Spurs may be rebroadcast by passive devices, such as rain gutters or abandoned radio towers. When that phenomenon is part of the problem, the investigator may have to use direction-finding equipment to trace the source.

Other spurs may be generated by a complex mixing of signals from many stations. The mixing may occur in transmitters, receivers and passive devices. Spurious emissions generated within the transmitting equipment often are called intermodulation interference, or intermod. Intermod is difficult to trace to its multiple sources because all components of the spur must be operating simultaneously for the offending spur to occur. "They may not all be operating when we get to the site," Young said.

Another difficult spurious-emission problem Young identified involves land mobile radio and high-power broadcast stations operated in the same area. "The broadcast transmitter may meet technical requirements for suppressing spurious emissions to a certain level," he said, "but that level still may be high enough to interfere with land mobile receivers. Antenna sites with broadcast and land mobile equipment quite often are the biggest headaches. But broadcasters and radio communications system operators often want the same sites because of coverage requirements."

Expert help

• *Qualified technicians*—"We have not made a thorough study of whether technical violations result from poorly designed equipment or from operator deficiencies," Young said. "But I suspect more violations result from lack of proper maintenance and adjustment." He said most transmitting equipment



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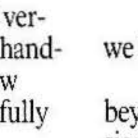

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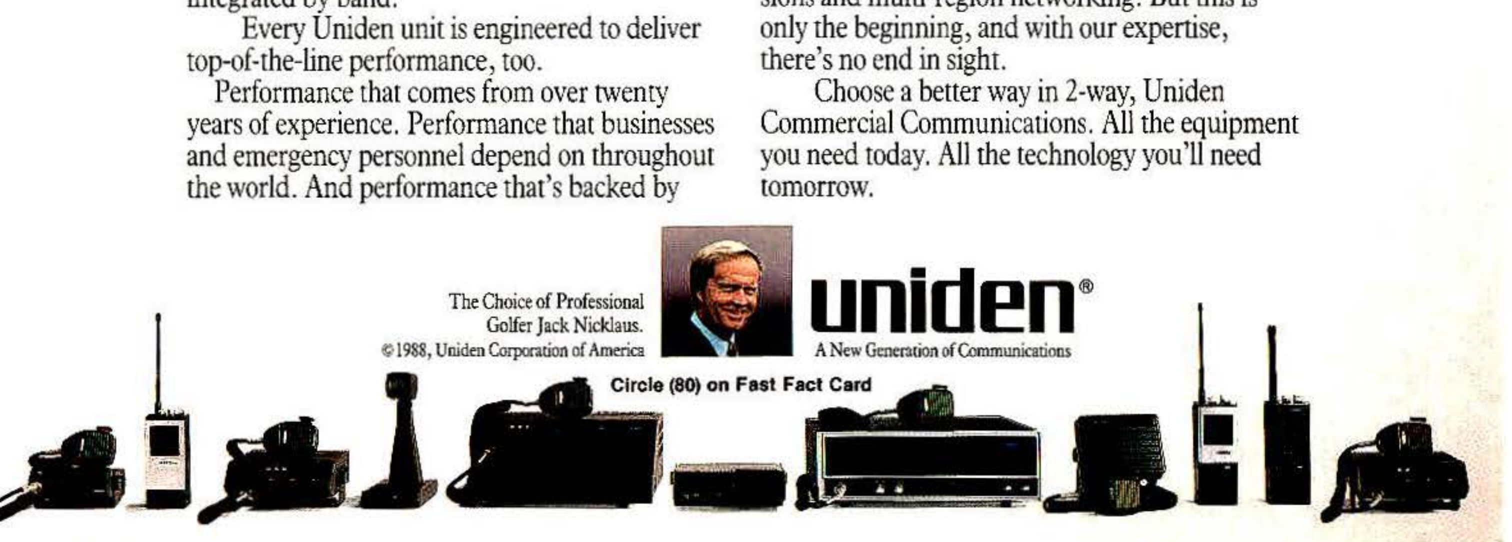

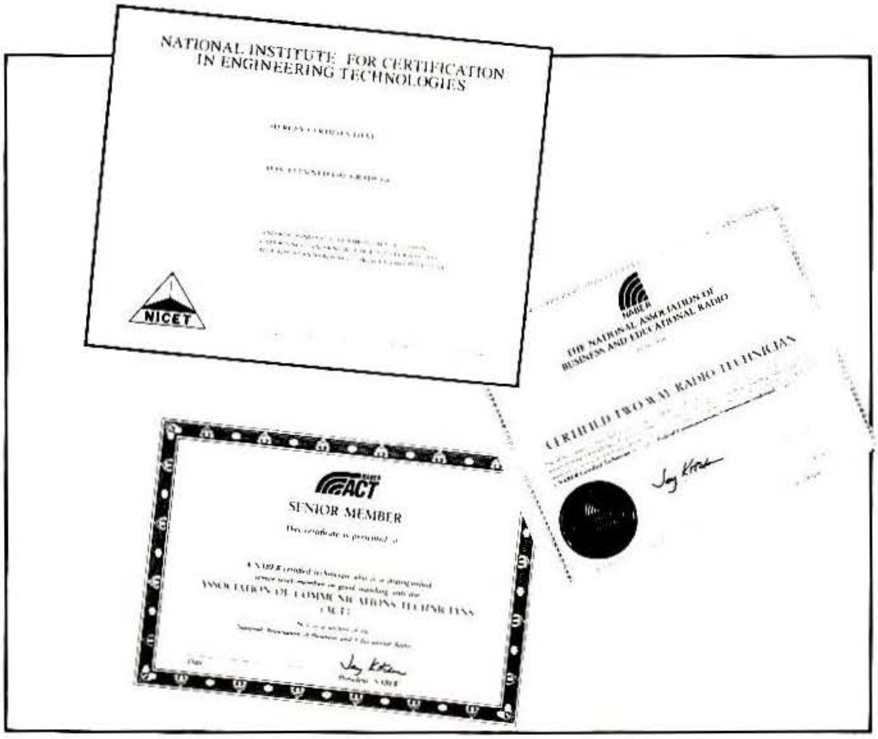

Certificates of technical competence and memberships in professional associations help to identify technicians who may be qualified to carry out transmitter service and maintenance.

must be type accepted, and therefore the manufacturer must meet certain standards prior to marketing the product.

"Nevertheless, if we see a trend indicating that a particular brand of equipment causes interference problems, we pass that information to our laboratory for study."

Young said that deviations from technical standards set forth on the license are more likely to result from equipment aging and lack of maintenance. With the use of solid-state equipment, even degeneration with aging has been brought under control to a certain extent. "Solid-state equipment does not generate as much damaging heat," he said.

• *Station identification*—"Failure to give station identification does not in itself represent a major problem," Young said. "But in conjunction with an interference problem, it becomes more serious. If the user does not provide the required station identification announcements, we may have to use

direction-finding or other signal signature analysis to identify the user."

Young said he would like to see the land mobile services adopt automatic transmitter identification encoding, as some other services have done. "It would make our job much easier when there is an interference problem. When you are trying to identify all the components of an intermod problem involving many stations, an identification transmitted each time the transmitters are keyed would make the problem much easier to resolve."

He predicted that automatic transmitter identification encoding will become more common in years to come "because it serves the user, too. Giving the ID is burdensome."

• *Short transmissions*—"I don't know if we have any hope of seeing that happen," Young said, referring to the FCC requirement that users keep their transmissions to the minimum practicable transmission time.

"I do not see the length of transmissions as having been a big problem, nor has it gotten much worse or better over the years," he said. "With more and more co-channel users, users may be forced to some extent to shorten their communication or they will upset other users. Feuds develop. We like to stay out of that."

'Failure to give station identification does not in itself represent a major problem.'

Young's advice: "Keep it short and you will avoid a lot of problems."

• *Harmful interference*—"Probably the most frequent complaint I hear is 'So and so didn't listen before transmitting.' Those complaints often come from taxi or towing services.

"The drivers are so tied up in their businesses that they treat the radio as though it were a telephone. They do not take time to make sure the frequency is clear; they just blast out and get out their message." Young observed that some taxi drivers in some major cities may not understand English well enough to understand a complaint that comes across the air.

Yet the FCC seldom becomes involved in resolving disputes over airtime use and monitoring before transmitting. "We use our limited resources to solve technical problems that need our expertise. It doesn't take a genius to point out the need for simple, common courtesy

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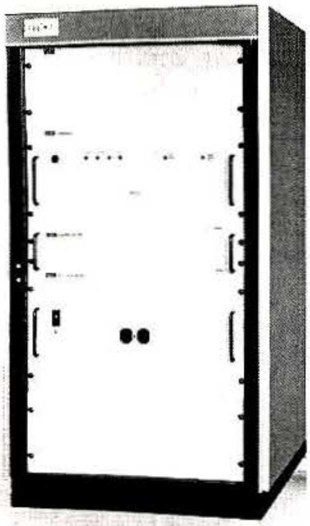

Joe Fitzsimmons, with Bob Luka and Frank Trainor of EMCEE, examines Cellular System Design

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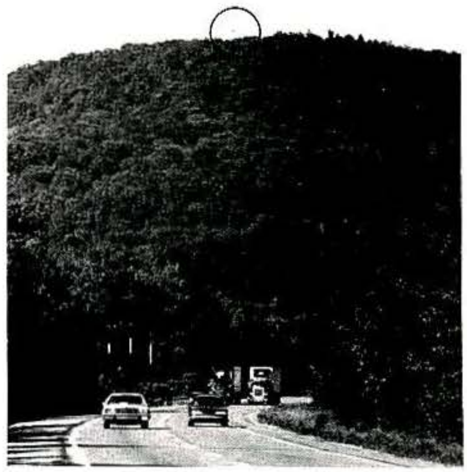

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when you share a channel, as with ordinary, face-to-face communication. You should keep it short and listen before you transmit," Young said.

• *Reports*—Land mobile radio system operators are self-policing, in a way, when it comes to making sure they comply with channel loading and facility construction requirements. What that means is that their competitors may complain to the FCC if they suspect reports filed with the commission are inaccurate.

"A good portion of our enforcement work originates with Private Radio Bureau (PRB) requests that we verify reports filed by licensees," Young said. "The PRB may be told that a certain system has not met its deadline for construction or for loading its channels with the required number of mobile units. They ask us in the FOB to investigate. If violations are substantiated, the PRB can recover unused or underused channels for reassignment."

In assessing the FOB investigation and inspection branch's workload, Young said the bulk of the work involves investigating channel loading and interference caused by spurious emissions. "All the rest of the cases are relatively minor."

Land mobile radio system operators are self-policing, in a way, when it comes to making sure they comply with channel loading and facility construction requirements.

Unlicensed operation

Young said the number of complaints about unlicensed operation has been growing.

"Some operators install community repeaters and initiate service for a number of users before filing license applications," Young said. Community repeaters do not require licenses, but their users do. These operators apparently falsely assure their customers that they may use their radios prior to applying for licenses or while their applications are pending.

"When we catch the unlicensed users, we usually issue a notice of apparent liability (a fine) and order them off the air," Young said. The fine may be as much as $2,000.

"What concerns us quite a bit is that, of the unlicensed users, a good portion are unintentional violators," he said. "They take the community repeater operator's word for everything. We are looking into the situation to see what action should be taken."

Installing mobile radios: Tips from the field

From power wiring to antenna placement, careful mobile radio installation undertaken with the police officer-driver in mind leads to the best results. Here are some practical considerations.

By R. Scott Gilmore

Installing mobile radios requires compromises:

• To satisfy the driver and radio user, controls should be accessible, or "user-friendly." Connectors, wires and the like should be concealed.

• On the other hand, the technician should not have to tear everything apart to make repairs, either!

County fleet

Saginaw County's fleet includes nearly 100 vans, buses, cars and boats assigned to many departments. VHF or UHF radio: Equipment—sometimes both—is installed in the mobile units.

Installation requirements may differ widely, but there are some common considerations: Equipment needs to be placed, powered, operated and repaired—safely.

Obviously, there is no single "right" way to install equipment. The following information is presented as "food for thought."

Inside controls and safety

Buses and police cars are the most critical vehicles. They serve as their drivers' "offices." They are on the road daily, in all types of weather and situations, with a high exposure to accidents.

Equipment installations in these vehicles must meet special operator safety requirements, some of which are state law.

Fancy Christmas-tree brackets, firmly bolted in place, have caused officers to be pinned inside when their cars have been involved in traffic accidents. Use the plastic brackets supplied with the control head. They are supposed to shatter on impact and allow the equipment to fall out of the way. (See Photo 1 above.)

Light control switches and mic hang-up boxes, when mounted beneath the instrument cluster, can painfully injure a kneecap in a hard stop. Mount them as high as possible and practical.

Mic cords have an uncanny attraction for being wrapped around steering wheels and shifter stems—watch where

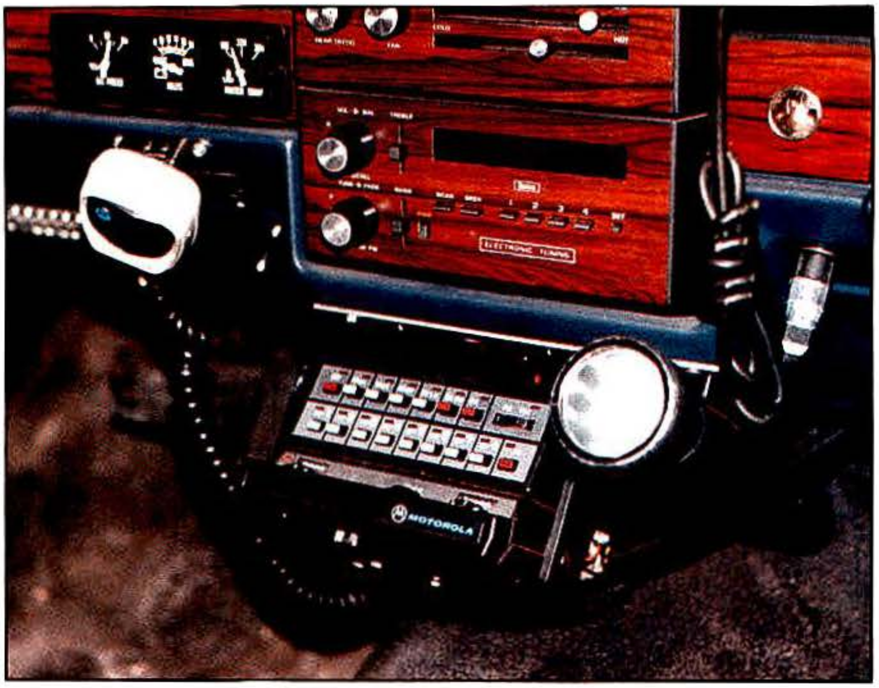


Photo 1. Plastic brackets break away to avoid pinning the driver should the vehicle be involved in an accident. They are used to hold the control heads and flashlight. The control stack clears the floor, also for safety reasons.

Photo 2. Mounting the speaker on the ceiling, just above the rearview mirror, puts it out of the way, yet it may be heard without blasting.

Gilmore is the director of the Department of Communication Engineering for Saginaw County in Michigan.

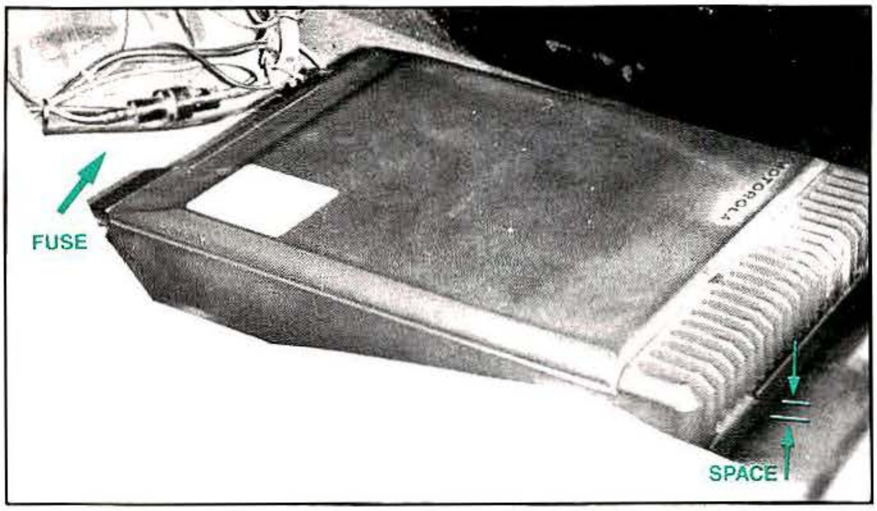


Photo 3. Mount the radio pan with three bolts placed through old PL-259 barrels as spacers. Fold the carpeting back before drilling the holes. Orient the radio connectors *facing forward*. Put the carpet back over the radio to reduce the amount of dirt that gets into the plugs. Note the 30A in-line fuse.

your cords may lead, and plan accordingly.

The radio speaker is probably the most difficult component to place. When placed on the far side of the transmission hump, it is behind other equipment, facing the wrong direction, and it cannot be heard well. Placing it on the sidewall is better, but it is exposed to damage from passengers' feet.

Try mounting the speaker on the ceiling, just above the rearview mirror. It will be out of the way, yet it it may be heard without blasting. (See Photo 2 on page 95.)

Use crimp-on quick-connects at the ends of common ac extension zip-cord for wiring, shoving it into the windshield top molding, behind the cornerpost, and behind the glovebox to the control stack. A bad speaker is easy to replace, and the wire can be abandoned at removal time.

Control cables

Keep cable damage to a minimum by routing cables along the vehicle's passenger side, away from driver-door traffic. General Motors puts a plastic trough there for vehicle wiring, and you can use it, too!

Place the cable along a route up and behind the glove box, *then* over to the control stack—*nothing* goes under exposed carpeting (more on that later.)

Trunk floors hardly ever are flat enough for mounting the radio pan. Use

old PL259 barrels for spacers; a three-point pattern keeps the pan from warping under tension, and you will be able

Fold the carpeting back before drilling the holes.

to remove the radio without suffering skinned knuckles.

Fold the carpeting back before drilling the holes. Orient the radio connectors *facing forward*. Put the carpet back over the radio to reduce the amount of dirt that gets into the plugs. (See Photo 3 on page 96.)

If the sheet metal is too thin to hold a screw, use ¼-inch bolts and 1-inch or larger fender washers on *both* sides of the floor. Treating the exposed threads on the underside with a coating of RTV will be helpful at strip-out.

Some installers avoid mounting antennas on the vehicle roof, thinking that a lightbar will distort the radiation pattern. Instead, they install the antenna on

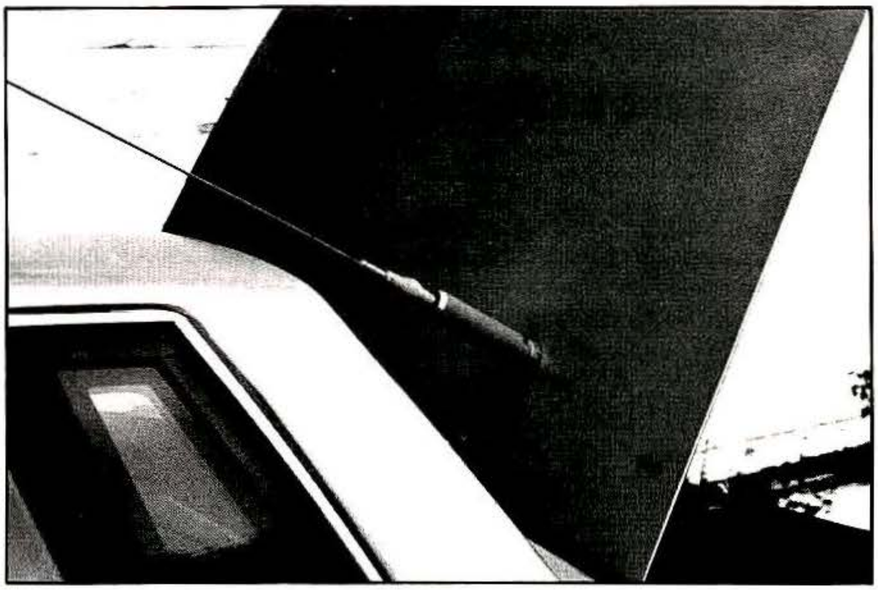


Photo 4. Secondary antennas can be centered on the trunk lid; take care that loading coils do not strike (or break!) the back window. Add grounding straps across *both* hinges if the factory forgot them.

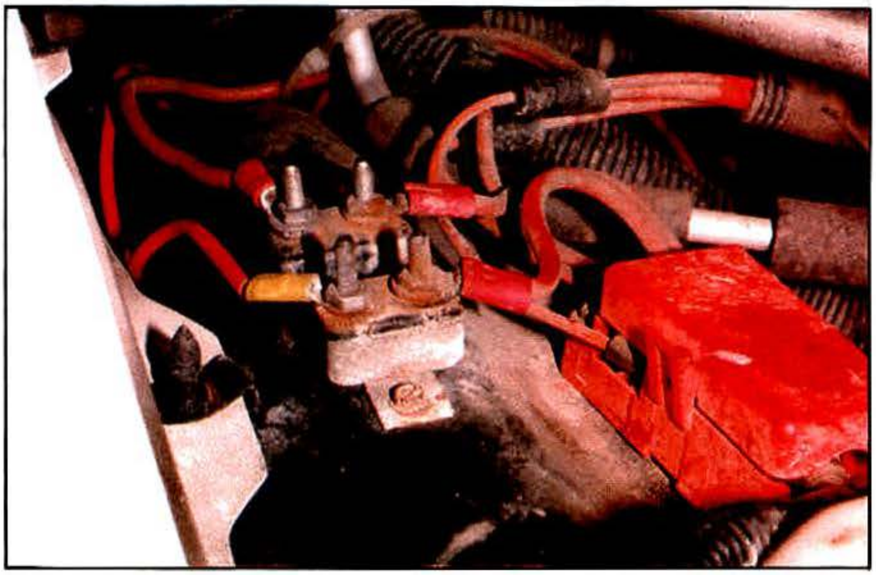


Photo 5. Mount a 40A automotive-type circuit breaker on the front wheel well for battery connections. The in-line fuse near the transceiver protects the electronics—the breaker protects your wiring—and your wires stay the same length for the next re-installation!

the trunk lid. But we have found that pattern nulls are worse when the signal has to compete with the lights *and* the roof-line. Unless there is an important reason not to cut a hole into the roof such as taking into consideration the vehicle's resale value, our primary channel antennas *always* go on the roof. Before drilling, check for hidden roof trusses, and remember to leave adequate ground plane around the antenna.

Secondary antennas can be centered on the trunk lid; take care that loading coils do not strike (or break!) the back window. (See Photo 4 on page 97.)

Add grounding straps across *both* hinges if the factory forgot them.

About those cute brackets behind lightbar speakers: They are fine for your CB antenna. Enough said.

Electrical and the firewall

Isn't it a pain to pull a 1-inch in-line fuseholder through a ¾-inch body hole on removal? Avoid that headache by putting the 30A fuse at the equipment end of the line (allowing a foot or so for working room). (See Photo 4.) Mount a 40A automotive-type circuit breaker on the front wheel well for battery connections. (See Photo 5 at the left.)

The fuse still protects the

electronics—the breaker protects your wiring—and your wires stay the same length for the next reinstallation!

Use additional breakers as required for lights, sirens and other electrical equipment.

Use additional breakers as required for lights, sirens and other electrical equipment.

When removing radio equipment from a vehicle, how often do you find the padding under the carpet a soggy, smelly, rotted mess? *No* grommet or sealer will ever keep splashed road water from finding a firewall hole.

Photo 6. To avoid water entry through the firewall, simply do not drill the firewall. Instead, drill the power lead entry hole beneath the rear seat. Use a ¾-inch antenna hole plug for a grommet, poking a hole just *smaller* than your wire size for a tight fit, and seal both sides with RTV.

Recommendation: Do not drill firewalls.

Instead, fish the No. 8 power wire *under* the car body, starting from the battery connection, under the blower fan, and along the frame. Make the entry hole below the back seat, and route the cable to the trunk unit from there. Do not route the power lead *anywhere near* the rear axle or springs.

Use a ¾-inch antenna hole plug for a grommet, poking a hole just *smaller* than your wire size for a tight fit, and seal both sides with RTV. (See Photo 6 on page 99.)

For those applications requiring high current at the control stack to power radars, sirens and light controls, fish the power lead behind the fender skin to the front door. Route it into the passenger compartment through the rubber boot containing the power window, lock and mirror wiring; then route it behind the glove compartment.

Similar recommendations for fuse protection apply: circuit breaker on the front wheel well; in-line fuses near the equipment.

Some vehicle computer systems can be extremely sensitive to voltage spikes, so do not wire anything to the vehicle fuse block unless it is absolutely necessary.

Finally

Check each part of the system as you go—*then* get out the wrappers and make it pretty!

Other thoughts

Silicone sealer, in its many forms, is handy for many applications, but a word of caution. Some types are hygroscopic—they will appear to *absorb* water.

Exercise care around antenna mounts; your ohmmeter may show a good line, but the wattmeter can read a short if some sealant has been dripped across the center conductor!

The problem has to do with the curing process; the "vinegar" smell is acetic acid—a pretty fair electrolyte, or conductive liquid—and exposure to the atmosphere is a requirement for proper setup. Make sure your seal can breathe.

Do you try to salvage and reuse old antenna mounts, feedlines and PL-259s? Compare the cost of new parts to the value of your time.

If your rate is $50 per hour, that $2 part better be ready to go in about three minutes, or you are losing money.

The same goes for bolts, screws, washers and wire.

Generally speaking, put the package together with these things in mind:

(1) Would you be comfortable with the installation if *you* had to drive the vehicle?

(2) Would you feel safe from unnecessary hazards in a traffic accident?

(3) Would you be cursing the installer if *you* had to make the repairs?

If you can be happy with the answers, then you have made an installation you can live with.

Radio Club of America presents certificates to 24 Fellows at its annual banquet

Twenty-four of the 35 members elevated to the grade of Fellow in 1988 received certificates during the Radio Club of America's annual meeting and awards banquet Nov. 18, 1988.

Standing, from the left, are: Connie Conte, Jay R. Huckabee, Norman D. Hawkins, Frank H. Jarvis, Antoinette P. Kaiser, John E. Brennan, Clive H.K. Moffat, George Graul, Harry L. Schmidt, Robert J. Elms, Joseph F. Marshall, George W. Weimer, Lloyd A. French, Anthony Natole, Arthur L. Greenberg and Herschel Shosteck.

Seated, from the left, are: Harry J. Mills, Gene F. Smith, Minnie Adams, Ake L. Lundqvist, William O. Hunt, Jacqueline H. Ericksen, *MRT* editorial director Don Bishop and John S. Sawvel Jr.

Coalition questions Federal Aviation Administration tests of lightning prevention systems

Competition between promoters of lightning protection and lightning prevention equipment enters the federal government arena with tests conducted by the Federal Aviation Administration. Lightning protection implies safeguarding electronic equipment from damage caused by high-current surges created by lightning; lightning prevention implies averting lightning strikes altogether.

The FAA has installed lightning prevention equipment on its airport radio control towers in Tampa and Orlando, FL. Products from Verda Industries are installed in Orlando; products from Lightning Eliminators and Consultants are installed in Tampa. According to Edwin Harris, the FAA's associate administrator for development and logistics, the agency seeks to discover whether the equipment, which is guaranteed to prevent a lightning strike, actually works. Harris expressed the agency's purpose in a letter to Rep. Martin Sabo (D-MN) of the House Transportation Appropriations Subcommittee.

The Coalition Against Non-Effective Lightning Protection Technologies (CAN'T) questions whether the tests adhere to the scientific method. CAN'T is a Washington, DC-based coalition of conventional lightning protection equipment manufacturers and installing technician companies.

Its executive director, Joseph Foley, stated: "The National Fire Protection Association, the Lightning Protection Institute and Underwriters Laboratories all have codes that address most conventional lightning protection technologies. [But] some of these more exotic lightning protection devices have not been adequately tested by a recognized private-sector organization or in an appropriate federal laboratory.

"Although it is commendable that the FAA has decided to test these devices," Foley continued, "several coalition members were alarmed that these test arrays were grounded to the conventional lightning protection systems already in place on the towers. Either someone at the FAA has concluded that a lightning bolt should be grounded if, in fact, a dissipation-type system cannot *prevent* lightning or there is some confusion at the agency regarding acceptable scientific method," he said.

SCE is granted Swedish contract

Spectrum Communications & Electronics, Hicksville, NY, has been awarded a contract to provide the Nordic Mobile Telephone System (NMT) with SCE PX2000 voice messaging systems.

Racing car driver Unser forms electronics company

Bobby Unser, founder and president of Trycomm. The company's first product introduction is a hand-held, crystal-controlled, 6W transceiver.

Bobby Unser, best known for his exploits as a professional racing car driver, has formed Trycomm, an electronics company.

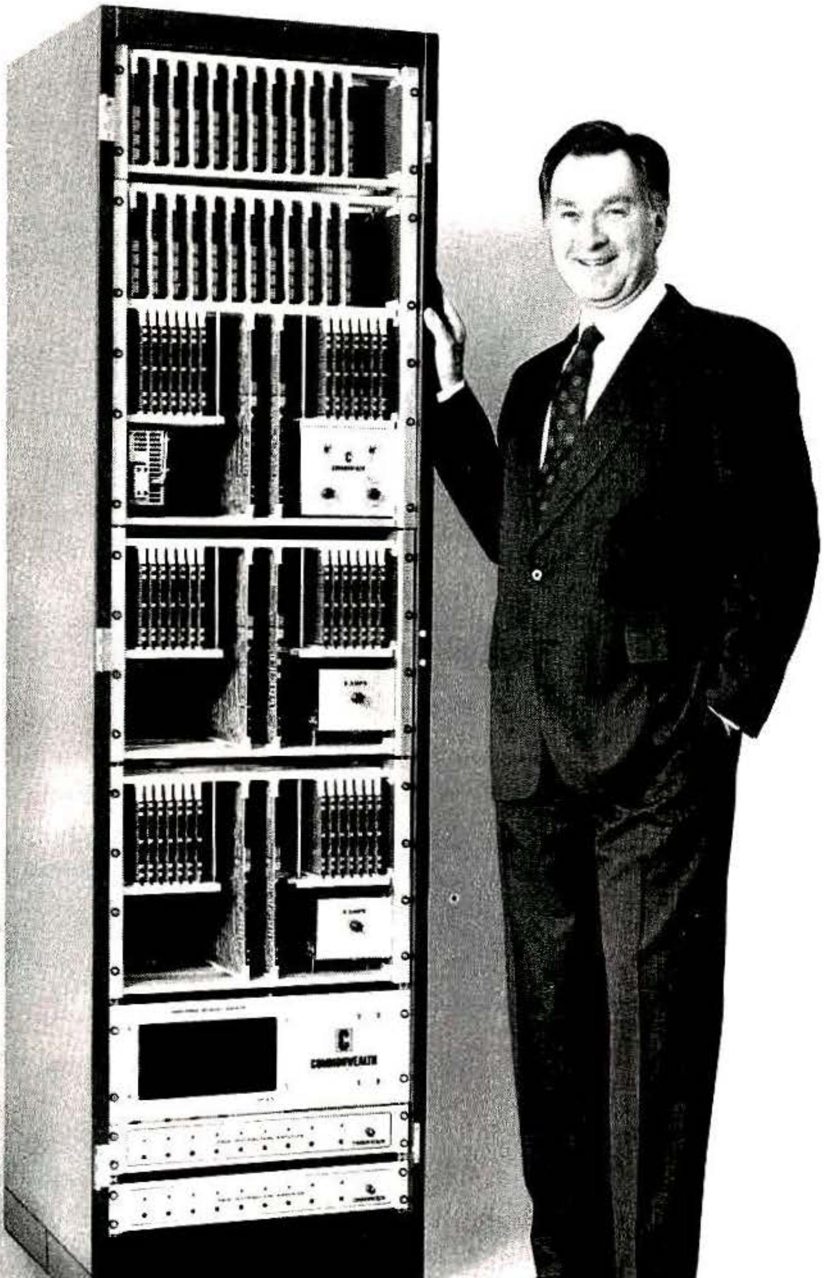
Trycomm, with offices in Fishers, IN, New York and New Mexico, was founded in mid-1987 to market consumer and industrial products. The first product it has offered to two-way radio dealers is a crystal-controlled, hand-held, 6W transceiver. Model TR-105 is manufactured "mostly in Japan," according to Steve Crum, who manages the Fishers office.

"It is basically a bread-and-butter radio" that competes with many similar units available. "Our beginnings may be humble," Crum said, "but we have a lot of stuff coming. We hope other efforts will be a lot different."

Trycomm's administrative offices are in New York, and "New Mexico is where our race driver friends tear the heck out of everything we make," Crum said.

Warehousing, ordering and shipping is conducted from Trycomm's facility at 15 Technology Drive, Fishers, IN 46038; 317-845-7436.

Talk To The Two Old Reliables In The Industry



Ted Faust, Commonwealth's Vice President of Sales and Marketing

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Motorola wins the first Malcolm Baldridge national quality award

President Ronald Reagan presents Motorola chairman Robert W. Galvin with the Malcom Baldrige National Quality Award at White House ceremonies Nov. 19, 1988.

Motorola, Schaumburg, IL, was one of three companies presented with the first Malcolm Baldrige national quality award for initiative in managing and improving quality processes, products and services.

The presentation was made by Commerce secretary C. William Verity and President Ronald Reagan on Nov. 19, 1988.

Motorola chairman Robert W. Galvin said, "While this distinguished award recognizes us for our outstanding quality management systems, we realize that there is more to do."

Omnicron relocates

Omnicron Electronics has moved to facilities at 581 Liberty Highway, Putnam, CT 06260; 203-928-0377. The new building has three times the space of the previous facility.

Louis Antoniou forms Antel

Louis Antoniou, former vice president of cellular communications for Hauppauge, NY-based Audiovox, has formed Antel Corporation, a supplier of cellular telephones and peripheral products worldwide, with primary concentration in North America.

The company currently has distribution centers and engineering and technical support staff in the New York, Chicago and Los Angeles. All facilities maintain an inventory of spare parts, as well as product. A service center network of more than 350 locations is expected to be in place early this year. Antel's first product is the Radiant 832XL cellular phone. Its future product line will include transportables and hand-held portables. Antel is at 67 Mall Drive, Commack, NY 11725; 516-493-0011.

Tait expands operation

Tait Electronics, Houston, is expanding its U.S. operation by adding 5,000 square feet of warehouse and shop area.

Selectone acquires Hyperdyne unit

Selectone, Hayward, CA, has acquired the exclusive manufacturing, marketing and distribution rights worldwide to the Hyperdyne interface unit. Selectone signed a license agreement with the developers of the product line, Don Cline & Associates, Houston, and Futronics, Tulsa, OK.

The ST-40 Hyperdyne interface unit allows an office telephone to serve as a base station remote. Option cards are available for the unit that allow paging operations and that make the interface compatible with trunked systems.

Bell Atlantic acquires Multicom paging assets

Bell Atlantic Paging, Parsippany, NJ, has acquired the assets of Dallas-based Multicom's paging sales and distribution business in Maryland, Virginia and Washington, DC. Bell Atlantic also offers paging service throughout most of New Jersey and Delaware, and in Philadelphia, Harrisburg and Pittsburgh, PA.

Richardson Electronics manufacturing CRTs

Richardson Electronics, LaFox, IL, has acquired instrumentation CRT manufacturing capabilities and has begun producing electrostatic deflection CRTs from its corporate headquarters.

The company will concentrate on manufacturing special purpose instrumentation CRTs with future production including magnetic deflection CRTs.

SCE sells another system to Cue Nationwide Paging

Spectrum Communications & Electronics, Hicksville, NY, will supply a nationwide paging system for use at Cue Nationwide Paging's headquarters in Irvine, CA. This is SCE's second sale to Cue. The system includes a redundant PX 2000 32-bit microprocessor system built with a 200,000-subscriber capacity. The system includes five cabinets and nine mirrored disks.

Motorola to supply Scandinavian system

Motorola Radio-Telephone Systems Group has signed a contract for a digital cellular system for the Danish, Norwegian, Finnish and Swedish Telecommunications Authorities.

The contract is for the supply of a working validation system for the four Scandinavian authorities, a important step toward planned implementation of the Pan-European digital cellular system in these countries.

The new contract follows the one granted to Motorola early in August by British Telecom on behalf of Cellnet in the United Kingdom and brings to five the number of European authorities that have selected Motorola digital cellular technology.

Uninterrupted cellular service offered between NY, Canada

Buffalo Telephone Company, Buffalo, NY, and Cantel of Toronto have completed installation of a cellular intersystem hand-off and automatic roaming provided by Ericsson, Richardson, TX. This feature gives cellular subscribers uninterrupted service between Buffalo and Cantel's Canadian network. These areas are the first to have automatic roaming and intersystem hand-off between the United States and Canada.

Nynex joins Telocator

Nynex Mobile Communications, New York, has joined Telocator as a paging member and becomes the fourth Bell regional holding company to join since Telocator reversed its policy of representing only non-wireline carriers. Nynex falls into Telocator's large member category.

Association president William Hotes said this action moves the association closer to its goal of representing the entire spectrum of mobile communications.

Scott Forsythe, Richard Sigel form Tempo Personal Comms

Scott Forsythe, a 15-year paging industry veteran, and Richard Sigel, a 12-year communications veteran, have formed Tempo Personal Communications, which offers paging, answering service and voice mail.

The company's first acquisition, a $3.83 million purchase of Beeper Call of Arizona and three associated answering service companies, serves the greater Phoenix area. Plans for expansion include Tucson.

The system is managed by Forsythe & Associates, a company formed in 1987 by Forsythe and Sigel to manage a series of stand-alone, separately financed paging operations.

Tempo is at 252 Clayton St., Suite 350, Denver, CO 80206; 303-399-3805.

C & B Electronics wins screen room

C & B Electronics, Auburn, NH, won a screen room from Pacific West Electronics, Costa Mesa, CA.

The screen room, valued at $1,156, was awarded in a drawing Dec. 25, 1988. A letter written by C & B's Barbara Cunningham was drawn from contest letters received at Pacific West Electronics by Dec. 20.

Century builds systems, sells Pine Bluff interest

Century Telephone Enterprises, Monroe, LA, is building an FM radiopaging system and a microwave network, and it is selling its interest in the Pine Bluff cellular system.

Through its subsidiary, Century Paging, Century Telephone Enterprises' FM radiopaging system in Florida will allow subscribers nationwide service in more than 100 U.S. markets.

Century also will construct a microwave transmission network in Michigan to transport Century Cellunet's cellular telephone, paging and message traffic.

Cellular Technologies Acquisition has agreed to buy Century's interest in the Pine Bluff, AR, cellular system. Century decided to sell because the market was not contiguous to its existing cellular operations.

Why join ACT?

The Association of Communications Technicians (ACT) is a membership section of the National Association of Business and Educational Radio (NABER).

Why join ACT?

- Senior member Michael Ball, of Newport, NC: "I joined to get the newsletter. It has been helpful in several instances. Our primary business is marine electronics."

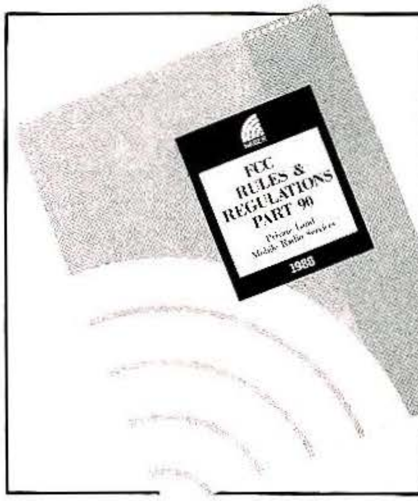
His initial electronics experience came with work he performed in TV repair facilities.

Ball took the NABER technician certification exam because he thought "studying for it would be a good way of checking how current I am in electronics. I used the study brochure NABER published at the time and I had no real difficulty passing. At the time, I was relatively new to the two-way radio field."

- General member Wayne Wantland of Yakima, WA: "ACT membership is in line with what we do. We wanted the information available through the organization."

Wantland said he finds interesting information in the association's newsletters. The "Test Yourself" section, he said, "is fun when we get the time."

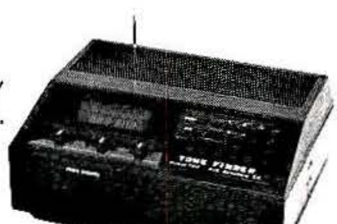
- Senior member Nathan Batson of Greenville, SC: "We have been members of NABER, and I thought it would be a good idea to join the ACT. Because NABER certifies technicians, it is a good idea to support the association."



ACT members may keep themselves up to date on FCC rules with a volume of Part 94 regulations printed annually.

Batson said he likes to pick up as much useful information as he can, especially because new technology is unfolding so quickly.

- Senior member John L. Beach of Panama City, FL: "I was looking for aids in management, technical tips and a way of staying up with the state of the art."
- Senior member Richard Beckum of Memphis, TN: "There wasn't any other group that represented us technicians. Everyone in our shop is a member of ACT."



Beckum said his shop has 10 ACT members. The founders of the service facility have NABER technician certificates obtained under the grandfather program that has since expired. "No one has taken the certification exam," he said, "but new technicians are encouraged to join ACT."

Training sessions

Beckum said technical training sessions conducted by manufacturers, NABER's monthly magazine and the ACT newsletter are helpful.

"Manufacturer sessions help a technician become familiar with specific equipment.

"The magazine helps with general theory and broadens a service specialist's perspective by exposing the technician to subjects that might not be covered in a tech's particular work.

"I bring the newsletter in and pin it up. It includes a technical quiz that we pass around to ask each other the questions. It keeps you on your toes."

Beckum mentioned the cloth patches available from ACT. "I would like us all to have coats with the patches to show we have done work in that area and excelled in that area." He said his technicians receive certificates from manufacturers upon completion of training courses. "Patches would be good to show we have specialized in a given area."

- Senior member Tom Wise of Brawley, CA: "Before the association was formed, the only thing to bond technicians together was the FCC license."

Directory

Wise said the *ACT Directory*, which lists members alphabetically and by geographic location, is ideal for use when traveling: "There is no other easy way to find other technicians to call when you visit another town. A lot of techs, when they are on the road, like to call other techs along the way. Many times, you have some good conversations. Otherwise, there aren't a lot of people you can talk shop with."

Wise said some of the larger service facilities have found advantages in having technicians discuss their work among themselves. "Lots of times just putting techs together lets them exchange information they can use to solve problems." He said that, with the directory, "it is possible to call around and check with other technicians. There is no other directory that lists technicians."

ACT has more than 2,000 members, of whom more than 80% have NABER certificates.

Information

For information about ACT, call 800-759-0300. Ask for "technician services."

Trunked systems may net conventional channels

Proposed new FCC rules would permit trunked radio system operators to apply for conventional (non-trunked) channels to add to their systems in the trunked mode.

Trunked systems automatically select open channels from a pool of frequencies licensed to one entity, a method that multiplies communications capacity of the channel pool. Adding a conventional channel to an existing trunked system, and trunking with the other channels, represents a more efficient use of spectrum than establishing a stand-alone radio communications system on the conventional channel.

The prospect of boosting spectrum efficiency moved the FCC commissioners to propose a rule that would allow operators of fully loaded trunked systems to apply for channels in the pool of 150 conventional channels in the 800MHz band. Fully loaded systems are those with a number of mobile users per channel that meets or exceeds a minimum fixed by FCC rules.

Channel-splitting comes to business radio service

Proposed FCC rule changes in PR Docket 88-373 would give access to 34 15kHz offset business radio VHF high-band channels: 22 in the Virgin Islands and Puerto Rico; 12 in the continental United States. The proposed changes include opportunities for high-power private paging operations.

"Although heavy use of the business radio service channels in the 150MHz band would limit the availability of the offset channels to new users," the agency's announcement reads, "the FCC is asking for comments on whether the presence of a frequency coordinator for the business radio service in the 150MHz band is sufficient justification to make all 15kHz offset channels available on a routine basis."

UHF-TV sharing remains blocked by TV proceeding

Efforts by private land mobile radio users to gain access to spectrum allocated for UHF TV broadcasting continue to be blocked by FCC consideration of comments in a notice of inquiry about advanced television (ATV).

ATV includes various proposed methods for improving the quality of TV pictures, such as high-definition TV, which would increase picture resolution. Among the alternatives proposed for an ATV spectrum plan are:

• no additional spectum allocation. (ATV must fit existing 6MHz channels.)

• use of 3MHz channels to supplement existing 6MHz channels. (The 3MHz channels would not necessarily be contiguous to existing channels.)

• use of additional 6MHz channels, not necessarily contiguous, to supplement existing channels.

• use of a supplemental 6MHz channel to simulcast ATV during a transition period, after which conventional broadcast signals would not be used.

Although new access to UHF-TV spectrum may be withheld from land mobile licensees, TV broadcasters themselves could be authorized to offer non-ATV service on supplemental channels. Alternative services would be offered only until the licensee constructed and began to use ATV broadcast capability. Authorization to offer alternative services would be for a limited time. The alternative services may include a form of communications capabilities similar to private land mobile, an idea that is not expected to be met with enthusiasm by current land mobile radio service providers such as specialized mobile radio system operators.

Taxicab alliance protests grab for 150MHz offset channels

The International Taxicab Association (ITA) disapproves a frequency allocation proposal initiated by the National Association of Business and Educational Radio (NABER).

NABER has asked the FCC to assign 12 offset frequencies in the 150MHz band for use by licensees in the business radio service in areas outside the statistical metropolitan areas (SMAs) defined by the 1950 census. Within those SMAs, the frequencies are assigned to the taxicab radio service.

ITA contends the demand for spectrum by taxicab radio users is sufficient to warrant assigning the frequencies for that service; NABER contends the opposite.

Commission issues report on frequency coordination

"Report to the Commission on Frequency Coordination in the Private Land Mobile Radio Services" discusses the origin of frequency coordination, the development of the coodination system and benefits and problems.

It is available for $20 plus postage or delivery charges from the FCC's duplicating contractor, International Transcription Services, 2100 M St. N.W., Suite 140, Washington, DC 20037; 202-857-3800. The publication number is 88-30.

Spectrum auction proposal survives in 1990 budget

The national budget prepared by former president Ronald Reagan's administration for fiscal year 1990 (Oct. 1, 1989, to Sept. 30, 1990) recommends a proposal to auction 6MHz of spectrum in the 800MHz band—as have previous budgets.

Although spectrum auctions never have won congressional approval, their estimated value continues to rise. Initial administration estimates put the spectrum value at $600 million. A House bill estimated the auctions would net $800 million. The 1990 budget places the value at $2.3 billion in 1990 and $1.1 billion in 1991.

Land mobile radio interests promote shared use of UHF-TV spectrum

Organizations representing land mobile radio interests exercised the latest opportunity to promote shared use of UHF-TV channels to the FCC.

The Land Mobile Communications Council (LMCC) and the mobile communications division of the Telecommunications Industry Association (TIA) filed comments in MM Docket No. 87-268. The docket is an FCC rulemaking proceeding whose objective is to chart the regulatory course for advanced television (ATV) broadcasting. ATV improves the televised picture. High-definition television (HDTV) is one form of ATV.

Some, but not all, developers expect ATV broadcasting to require additional spectrum.

LMCC supports rules that would require broadcasters to develop ATV signals within their existing 6MHz channel bandwidths. That would clear the way to implement shared use of UHF-TV channels along the lines of a plan already before the FCC.

But if additional spectrum is required, the FCC proposes to allocate it to the broadcasters, who would have the option to leave it dormant. They also would have the option of "leasing" it to land mobile radio users until the broadcasters decide to use it.

Although LMCC hopes the FCC will require ATV to be accomplished within current 6MHz channels, it has taken a position on this portion of the FCC proposal. It finds the "leasing" option to be "inappropriate" in part because it would force radio users to pay a broadcast entity to use spectrum the broadcaster would get for free.

Instead, LMCC wants radio users to have access, however limited, to UHF-TV frequencies on a shared basis. If and when ATV broadcasting begins in an area, radio users in that area would have to yield their channels.

TIA takes active positions that cover several alternatives:

- If ATV is held to 6MHz channels, then ATV developers should be required to design receivers capable of meeting interference standards proposed in the original land mobile/UHF-TV sharing proceeding.
- If ATV is held to 6MHz channels, the UHF-TV channel assignments across the country should be reshuffled, filling in the lower channels. Then, the upper channels should be reallocated for land mobile use.
- If ATV requires each broadcast station be allocated a second 6MHz channel for simulcasting or if ATV requires each broadcast station be allocated an additional 3MHz channel to augment its conventional picture, TIA concludes that sharing or reshuffling remain possible.

Trilectric Establishes National Distribution and Inventory

Trilectric, major supplier of:

- **Mobile Amplifiers/Chargers**
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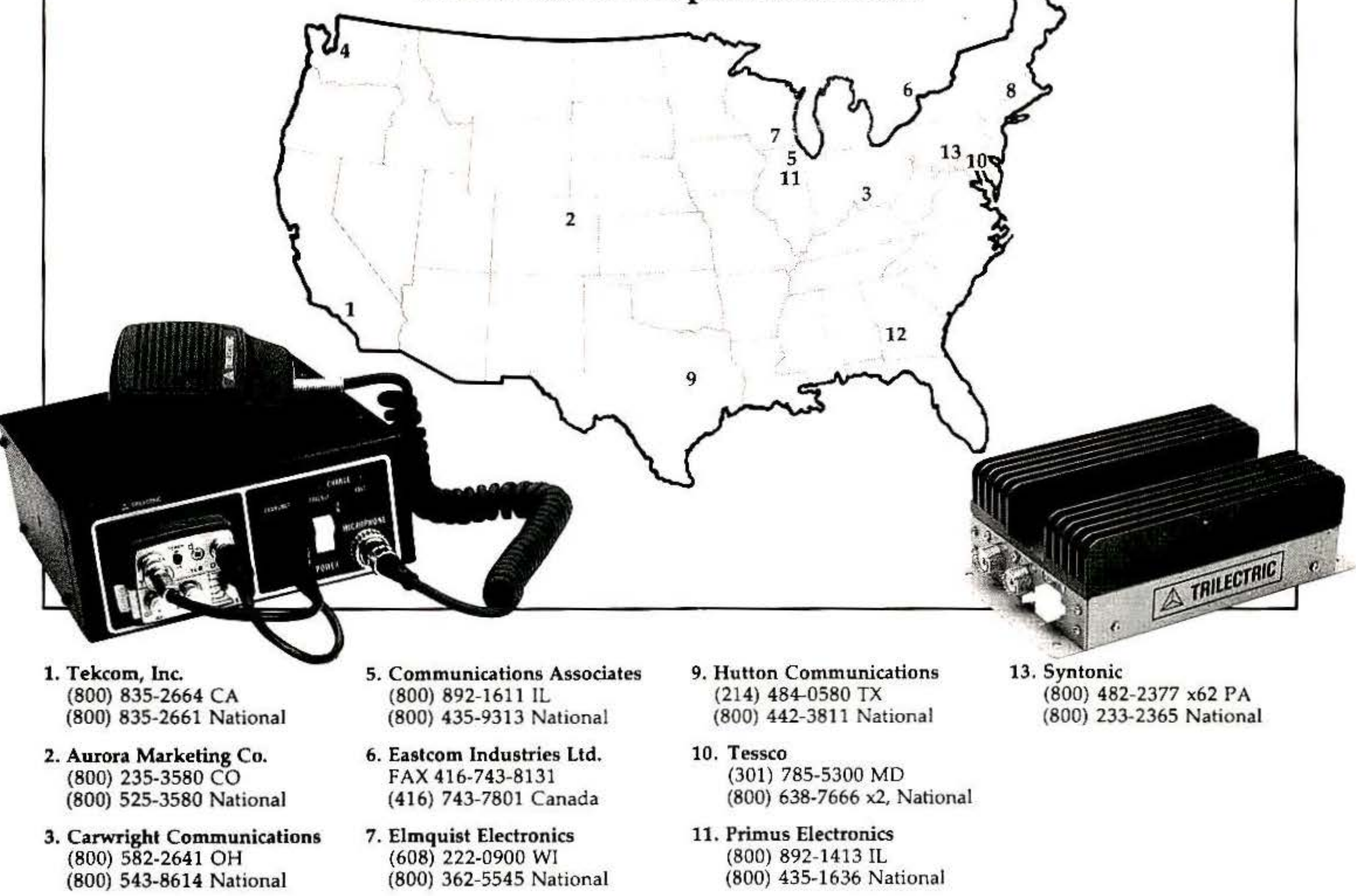
- **Base/Repeater Amplifiers**
- **VHF, UHF, 800 MHz**

is pleased to announce our newly established National Distribution and Inventory Program.

For the stocking distributor nearest you, please note the following list with their locations and phone numbers.



1. Tekcom, Inc.
(800) 835-2664 CA
(800) 835-2661 National

2. Aurora Marketing Co.
(800) 235-3580 CO
(800) 525-3580 National

3. Carwright Communications
(800) 582-2641 OH
(800) 543-8614 National

4. Cascom
(206) 624-7136 WA
(800) 282-AMPS

5. Communications Associates
(800) 892-1611 IL
(800) 435-9313 National

6. Eastcom Industries Ltd.
FAX 416-743-8131
(416) 743-7801 Canada

7. Elmquist Electronics
(608) 222-0900 WI
(800) 362-5545 National

8. Graham Radio, Inc.
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9. Hutton Communications
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10. Tessco
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(800) 638-7666 x2, National

11. Primus Electronics
(800) 892-1413 IL
(800) 435-1636 National

12. Radio Wholesale
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13. Syntonic
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Readers' choice

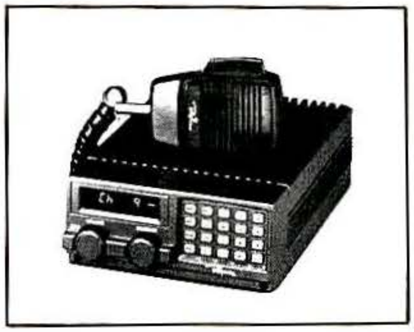
Of all the new products and services covered in the August 1988 issue of *MRT*, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, here is your opportunity to acquire more information on them: Just circle the corresponding Fast Fact number on the Fast Fact Card found in the back of this issue and mail the card to us.

Two-way portables meet simple communications needs

The Radius P10 and P50 two-way portables from **Motorola** offer CTCSS and DCS to reduce co-channel reception. Model P10 features single-channel, low-power operation in UHF and VHF. P50 is available in 2W or 5W models in VHF and 1W or 4W in UHF; it also offers one- or two-channel operation.

Circle (516) on Fast Fact Card

10-channel mobiles have built-in scan



The RM mobile radio line from **Regency Electronics** comes in three versions: RML, with 60W power in the 30MHz to 50MHz range; RMV, with 60W power in the 148MHz to 174MHz range; and the RMU, with 45W power in the 450MHz to 428MHz range. The radio has 10 channels, built-in scan, scan delay, time-out timer and 12-hour clock.

Circle (514) on Fast Fact Card

Portable satellite terminal takes 30 minutes to set up

The **ViaSat** portable satellite terminal can be checked as airline baggage and takes about 30 minutes to set up. The Ku-band VSAT earth station system can provide full duplex telephone and data communications simultaneously from any site, and the terminal is available for sale, lease or short-term rental.

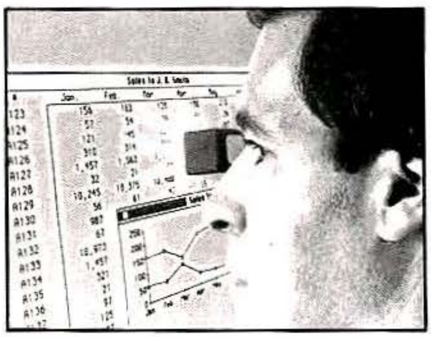
Circle (512) on Fast Fact Card

Lead-acid battery pack charges at 15A per hour

A high-power rechargeable lead-acid battery pack is available from **Communications Service Consultants**. The Mid-Pac 15 is a 15Ah battery for use with Midland 70 series radios.

Circle (304) on Fast Fact Card

Miniature display device serves as data monitor



The Private Eye miniature display from **Reflection Technology** provides the readability of a full-sized monitor in a 1"x1½"x3½" package. Using optoelectric technology, it can reduce the size of a product that incorporates a full-sized display and enhance an existing product by adding a full-screen display. The device can be held in front of a user's eyes or mounted on a headset. The image viewed in the unit appears to be 2 feet away and does not impede the surrounding background. With the unit attached or built into mobiles or pagers, technical information can be read to engineers, and route and delivery information to drivers. The device display uses less than ½W and can be battery-powered for portability.

Circle (313) on Fast Fact Card

Board tester's power comes from unit under test

Menu-driven testers from **Contact East** diagnose faults in microprocessor-based devices. The unit clips directly onto the processor to isolate memory and I/O problems. Power is supplied by the unit under test.

Circle (269) on Fast Fact Card

Antennas provide broadband directional gain

The Log Periodic antennas from **Transcrypt International** are lightweight and easy to carry and can be deployed in less than a minute. They offer maximum range extension for hand-helds and base stations and provide broadband directional gain. The antennas are designed for tactical, VHF and UHF communications and are available in several versions to cover frequencies from 100MHz to 900MHz.

Circle (515) on Fast Fact Card

Voice mail system suits SMR needs

An integrated voice mail system offered by **AmeriCom** complements its trunked network switching system. The voice mail system connects to the network via standard telephone lines. The voice mail capability includes mailboxes, call forward, message retrieval and message filing.

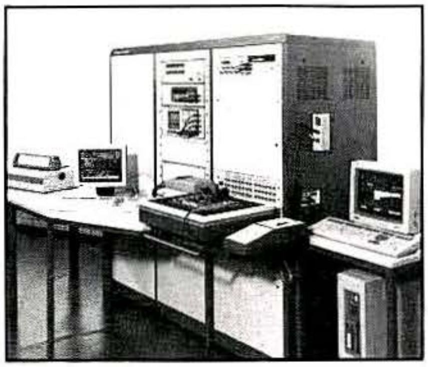
Circle (280) on Fast Fact Card

Trunk line enhancement allows faster call processing

The DID Maximizer trunk line enhancement from **Hark Systems** allows faster through-put of calls. Installation of the unit by paging and mobile telephone system operators allows compatibility with Type II interconnection signaling requirements. The enhancer translates MF signaling to a format compatible to existing equipment.

Circle (270) on Fast Fact Card

Mobile test set has autoset function



The mobile radio test set FMP 3 from **Rohde & Schwarz** incorporates fundamental capabilities for transceiver measurements and is portable. It features simple operation and autoset facilities. A detachable directional coupler probe is available for reflectometer measurements. An optional duplex modulation meter is available as well.

Circle (424) on Fast Fact Card

Trunked system identifies individual users

SmartWorks 800MHz single-site, trunked communications system from **Motorola** reduces congestions with an automatic allocation of a limited number of radio frequencies among many users. A push-to-talk ID-emergency call on the CRT display shows a visual readout of a unique ID code assigned to each mobile or portable radio user. In the event a failure occurs on the current control channel, a dedicated channel reassigns other voice channels to continue processing calls. Previous separate systems can be integrated on the SmartWorks system to meet individual needs.

Circle (216) on Fast Fact Card

Speaker amplifies hand-held audio

The HTS-1 amplified speaker from **Naval Electronics** features a 10dB audio amplifier and oval speaker to boost hand-held sound. A battery-saver circuit shuts off the audio amplifier if a hand-held is squelched for more than 10 seconds. A dc power jack and voltage regulator enable use of any external voltage from 5Vdc to 15Vdc. Features include automatic shut off, built-in nicad charger, LED display status indicator and titled base.

Circle (305) on Fast Fact Card

Monitor receives from 100kHz to 2,036MHz

A monitor from **Ace Communications** receives SSB, CW, AM, FM wide and narrow modes from 100kHz to 2,036MHz. The radio operates on 13.8Vdc and can scan four banks of 100 channels each. Each bank has a priority channel to override calls on other channels. The receiver's frequency coverage is split into two groups: 0.1MHz to 30MHz and 30MHz to 2.036GHz.

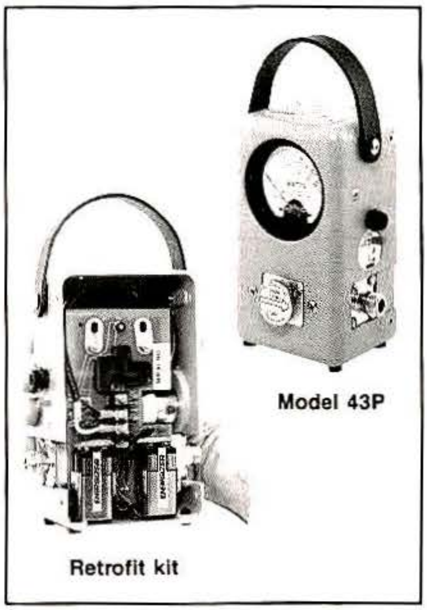
Circle (226) on Fast Fact Card

Paging transmitter serves private carrier systems

The DPT 100 digital paging transmitter from **Neutec** is designed for private carrier paging systems and is available in lowband, midband VHF and UHF. Each unit offers a minimum of 80W of transmit at 100% continuous duty. Control circuitry allows analog and digital paging formats. The units have front-panel controls.

Circle (283) on Fast Fact Card

Wattmeter comes in true peak power version

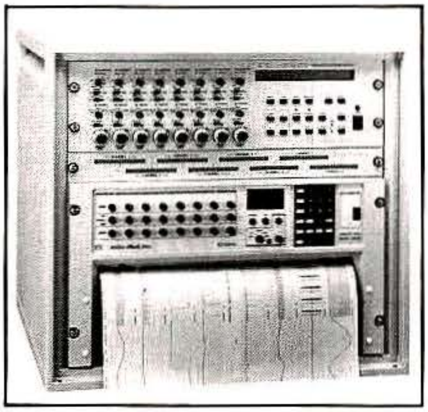


Model 43 wattmeter from **Bird Electronic Corporation** is available in a true peak power reading version, model 43P. Measurement of true peak power of SSB and AM modulated RF, as well as some rectangular limited pulse signals, is feasible with model 43P. No special plug-in elements are needed for peak measurement. Depending on the element selected, the overall frequency range of the tester is 450kHz to 2.3GHz, and RF power range is 100mW to 10,000W. The standard model 43 wattmeter can be modified with a retrofit kit, model 4300-400, to obtain the same peak power measuring capability as model 43P. The retrofit kit includes a pc board that mounts inside model 43, and conversion time is less than 15 minutes.

Circle (233) on Fast Fact Card

New products

Data capture system increases frequency response



The TC-2500 data capture system from **Astro-Med** increases the response time of its MT-5900 eight-channel recorder from 5kHz to 200kHz. The unit samples eight channels simultaneously at rates as high as 2MHz per channel.

Circle (277) on Fast Fact Card

Test controller includes cell-site simulation

The ZK-1200-A cellular test controller for the IFR 1200 from **ZK Celltest Systems** provides hands-off automatic test of cellular phones. Audio connections to the mobile phone are provided by a high-fidelity acoustic coupler. Mobile test control signaling, which simulates a cell site, is done via the mobile antenna port.

Circle (211) on Fast Fact Card

Voice prompts are option for paging terminal

Circle (240) on Fast Fact Card

Model 64 Dapt-Plus paging terminal from **Zetron** supports 1,000 pagers and is field-programmable, including paging format. It offers as many as three telco interfaces, four transmitter-zone steering, duplex or simplex talkback paging and various paging formats. An optional voice-prompt card may be installed; it holds as many as eight messages.

Circle (120) on Fast Fact Card

Circle (121) on Fast Fact Card

Static control line contains anti-static guard

A line of static control cleaners from **Tech-Sa-Port** incorporates an anti-static guard element. Contaminant-free products offered include anti-static CRT screen cleaner, anti-static treatment, disk cleaning solvent and cleaning pads.

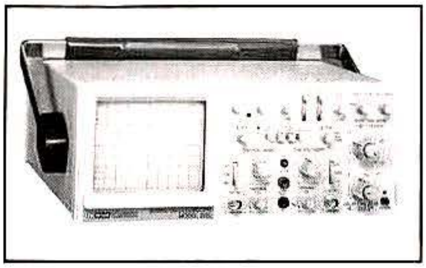
Circle (408) on Fast Fact Card

Land mobile, marine units offer 80 channels

Two VHF marine-land mobile transceivers from **Midland LMR** are programmable for as many as 80 channels and are available as one-piece or remote-mount units. The synthesized Syn-Tech radios, models 70-343A/443A provide 25W output, switchable to 1W. Models 70-343/443 offer an adjustable RF output of 20W to 40W. The units feature programmable busy channel lockout and time-out timer.

Circle (202) on Fast Fact Card

Dual-trace oscilloscope includes delayed sweep



The 2125 20MHz dual-trace oscilloscope from **B&K Precision,** a division of Maxtec International, has delayed sweep and features 1mV per division sensitivity. The scope has a built-in component tester for capacitors, inductors, diodes, transistors and zener diodes. Delayed sweep operation covers from 0.1 microsecond per division to 50 milliseconds per division in 18 steps.

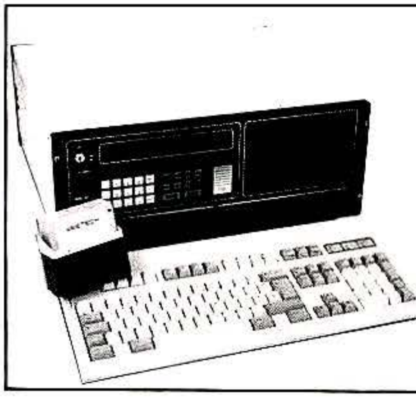
Circle (436) on Fast Fact Card

Wireless modem enables local area networking

The ESTeem model 85 wireless RF modem from **Electronic Systems Technology** allows local area networking. The unit's frequency-agile VHF narrowband transceiver provides more than 600 radio frequencies for modem operation. As many as 255 users on each frequency can be networked. Data flow is controlled by user-selectable hardware or software handshaking. The modem offers private data communication and an operating range of 10 miles to 15 miles.

Circle (421) on Fast Fact Card

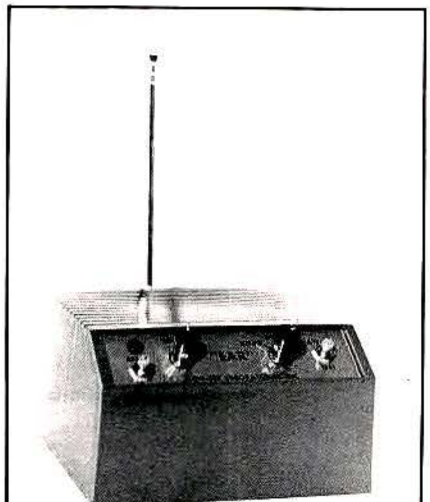
Interconnection testers measure opens, shorts



Low voltage interconnection testers from **Weetech** measure cables, cable harnesses, backplanes, wiring systems, resistors, diodes and switches. Model 23 performs point-to-point tests for opens and shorts for as many as 8,192 test points. Model 22 performs the same function for as many as 512 test points. Test voltage for both units is 10Vdc with current ranges of 0.1mA to 10mA.

Circle (423) on Fast Fact Card

Radio alert system covers three ranges



The EAR emergency alert radio system from **Com-Ser Laboratories** covers lowband VHF, highband VHF and UHF frequency ranges. Three different receivers are available to cover one of these ranges.

Circle (415) on Fast Fact Card

Trunking mobile offers cloning capability

Model SM-1020T SMR trunking mobile from **Neutec** features a "no-tune" RF design. The mobile allows as many as 10 groups and areas to be programmed. It can program conventional 800MHz frequencies. Transmit power is 15W to 20W, adjustable. Features include time-out timer, call alert LED, system-track lock, system scan and through-the-mic programming. Cloning is possible with a cloning cable or optional hand-held memory unit for cloning and reprogramming.

Circle (282) on Fast Fact Card

Billing software details dispatch, interconnect use

System 3000 mobile billing software program from **I.D.E.A.** for GE Marc V and Motorola SMR operators itemizes billing for dispatch and interconnect mobile radios using flat-rate airtime, time-segmented rates and multiple unit billing rates. The operator may specify rates for each ID and tone set. A detailed list of calls is available.

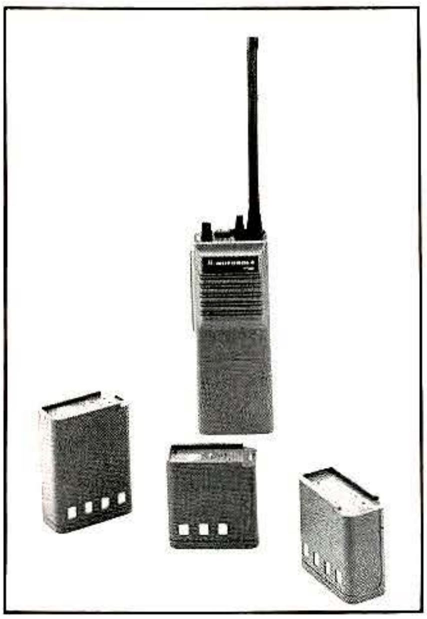
Circle (314) on Fast Fact Card

Multivoltage system protects against shorts

The DUVAC II line of dual voltage alternator controls protects against reverse polarity, loss of ground, short circuit, over current, over voltage and low voltage. Model 52103C from **Sure Power Industries** is a 24V to 12V, 25A converter. A primary application would be in conjunction with installing a 12V radio onto a 24V chassis.

Circle (310) on Fast Fact Card

Replacement battery packs fit Motorola HT-600



Replacement battery packs for Motorola's HT-600 series are available from **W & W Associates.** WC-060J-563A replaces Motorola NTN4563A; WC-060K-4584A replaces NTN4584A; WC-060L-4588A replaces NTN4588A; and WC-060M-4585A replaces NTN4585A.

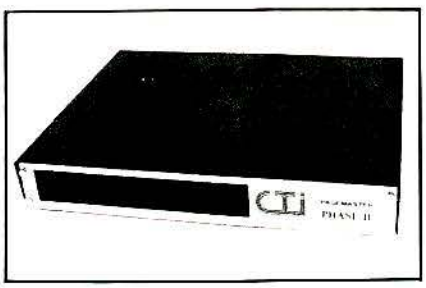
Circle (291) on Fast Fact Card

Mobile amplifier covers 800MHz broadband

The A-2050T 800MHz amplifier from **Trilectric** division of Celltronics is broadband and covers 806MHz to 821MHz. It provides 40W to 60W RF output and features solid-state switching.

Circle (284) on Fast Fact Card

Paging terminal upgrades include HSC encoding

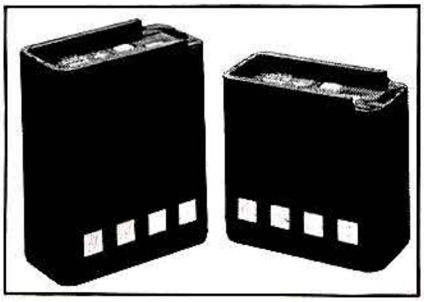


The Page Master Phase II paging terminal upgrades include HSC and digital voice prompting. The terminal from **CTI** has analog and digital encoding capability. As many as four messages may be used. All custom features are provided on a per-subscriber program basis from a menu-driven CRT and keyboard.

Circle (236) on Fast Fact Card

New products

Replacement batteries fit Motorola MTX800, MTX1000



Two replacement batteries for Motorola radio models MTX800 and MT1000 are available from **Alexander Batteries.** Battery H4822 replaces Motorola NTN4822A and NTN5047A and offers 10V, 600mAh capacity. It accepts a rapid charge. The H4824 replaces Motorola model NTN4824A and NTN5094A and offers 10V, 900mAh capacity. It accepts a rapid charge.

Circle (382) on Fast Fact Card

Tone panel regenerates 37 EIA CTCSS tones

The TIC-100 CTCSS repeater panel from **Pacific Circuit Design** features fast transmitter rise time and advanced remote DTMF function control. Standard features include 37 EIA CTCSS regenerated tones, CW identifier, repeater maker circuitry, courtesy beep, remote DTMF control, five-digit security code, time-out timer and transmit hang time. The operating voltage is 8Vdc to 18Vdc.

Circle (250) on Fast Fact Card

Display cabinet fits repeater controller

A display cabinet option from **S-Com Industries** for its 5K repeater controller can be retrofitted to any 5K controller without soldering and rewiring. The cabinet sports a non-chipping black anodized front panel, white graphics and the use of hidden fasteners. LED lamps inform the viewer of important circuit status data and consume only 1mA each. A conductive iridite-plated chassis box reduces RFI and houses the 5K board, display board and an optional audio delay module.

Circle (219) on Fast Fact Card

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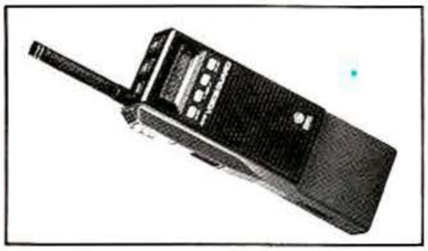
Circle (154) on Fast Fact Card

Encryption device allows 64 channels wideband use



The M-PD VGE (Voice Guard encryption) personal radio from **General Electric** is available in VHF and UHF and provides high level security using the proprietary, exportable VGE algorithm. Encrypted range is equal to clear range, and the unit offers 64-channel wideband operation. Field programming is possible without opening the radio. Functions can be customized with any IBM-XT or AT compatible PC. An illuminated alphanumeric LCD display provides instant visual identification.

Circle (217) on Fast Fact Card

EEPROM multiprogrammer features 9 function keys

The Ez-Writer (E)EPROM multiprogrammer from **Bytek Corporation** supports 24-, 28-, 32- and 40-pin MOS and CMOS EPROMS and EEPROMS with as many as 1,024K bits without personality modules or adapters. Required voltages and waveforms are generated under software control. The unit has nine function keys, and operations include load, edit RAM data, program, blank check, verify device, fill RAM, display device data and sum check RAM/master. Four operating modes include stand-alone programming for data editing using a 25-key, integrated keyboard and a 40-character alphanumeric LCD; terminal remote control using the standard serial RS-232C; computer remote control mode via the RS-232C and five translation formats; and software that provides menu-driven operation.

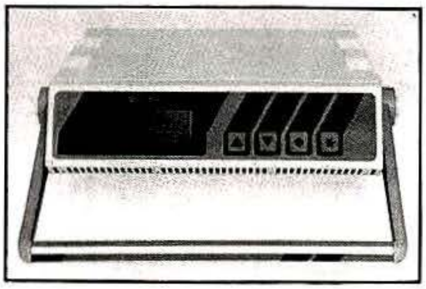
Circle (227) on Fast Fact Card

Test probe accepts 22 to 18 AWG wire

Model 5432 miniature test probe from **Pomona Electronics** accepts 22 to 18 AGW wire sizes with a maximum of 0.115-inch diameter insulation. The probe tip is made of nickel-plated brass, and the probe barrel is molded of nylon. It is available in red or black.

Circle (271) on Fast Fact Card

Cellular phone tester provides automated test



The DB1965 cellular telephone tester from **Decibel Products** provides an automated test capability by connecting the DB1965 Cel-Tel portable tester to the mobile antenna's connector and selecting tests from the unit's four push buttons. The tester weighs less than 8 pounds, and with optional add-on instruments, the unit's capability can be expanded. The unit comes with internal batteries, RF cable, 30dB attenuation pads and ac power cord.

Circle (261) on Fast Fact Card

VHF hand-held adds recharging capability

The Courier Procom VHF portable from **Fanon Courier** can be recharged with a drop-in charger adapter, model DIC-1. The charger is used with the company's CHB-7 battery charger. An earphone jack is new to the radio, as well. The 2W radio is available in one of the following business band frequencies: 151.625MHz, 154.570MHz or 154.600MHz. An adjustable squelch control, volume control and external antenna are standard.

Circle (247) on Fast Fact Card

Lithium AA cell battery offers 3V, 600mAh capacity

Circle (252) on Fast Fact Card

The Molicel² AA cell rechargeable lithium battery from **Moli Energy Limited** offers 3.0V nominal and 600mAh capacity. The rechargeable cell provides 200 charge-discharge cycles in typical applications. One lithium cell can replace two AA size conventional rechargeable batteries in most applications.

Circle (130) on Fast Fact Card

Portable antenna fastens in vehicle with suction cups

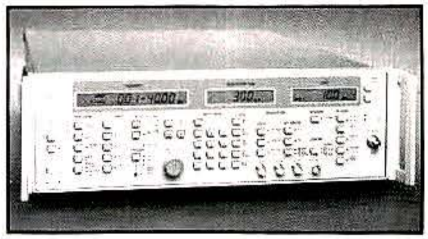
The AM 850SC portable cellular antenna comes complete with suction cup mounts for attachment inside vehicles. The 3dB half-wave antenna from **Valor Enterprises** is provided with TNC connectors and 17 feet of cable and comes in black, red and white.

Circle (432) on Fast Fact Card

Microwave synthesizer covers 10MHz to 40GHz

The 6769A microwave synthesizer from **Wiltron Company** covers a wide frequency range of 10MHz to 40GHz. The synthesizer has a built-in internal pulse generator, power meter and pulse modulator. The unit meets EMI requirements for military standard 461B.

Circle (220) on Fast Fact Card



Remote display unit contains menu-driven software

The CSI-12 remote display unit from **Communications Systems** supports the control of the CSI series community repeater tone panels. The unit features menu-driven software that, when used in the "intelligent mode," will not allow the operator to enter incorrect commands. The display unit can be used with a printer and print a two-page listing of the Super-32 and 32-Plus program mode and data retrieval commands.

Circle (265) on Fast Fact Card

Rechargeable batteries fit portable transceivers

Rechargeable batteries for two of its portables are available from **Midland LMR.** The 70-B34 fits the Syn-Tech 80-channel portables and has 1.8Ah with 12 hours of service at 5W and 16.5 hours of service at 2W. The 70-B26 is 1.0Ah and 13.2V and fits the company's 16-channel synthesized portables. It enables 5W output, rather than 2W from the previous battery.

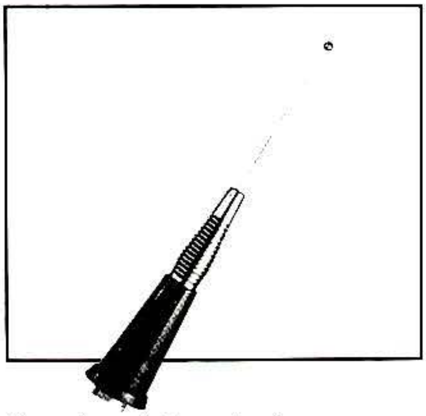
Circle (410) on Fast Fact Card

Repair kits help to fix connectors, boards

The CIR-KITS from **Pace Electronics** aid in the repair of damaged or missing lands, plated-through holes, conductors and edge connectors on printed circuit assemblies. The kit contains more than 30 sizes of eyelets, tracks that are plated to military specs, abrasive stick, setting tool and instructions. Three models of kits are available to suit various types and levels of repair.

Circle (416) on Fast Fact Card

Antenna whip offsets windloading effect



The Spectrum line of antennas from **Motorola** features a heavy-duty tapered whip that reduces the windloading effect. Antenna versions for lowband, highband and UHF are included among the 17 models in the line. The coil housing withstands temperatures of −40°C to 85°C. Roof-, magnetic- and trunk lid-mount antennas are available. Antennas are constructed with corrosion-resistant materials.

Circle (249) on Fast Fact Card

Page input terminal has 80-character display

The Alpha 200 alphanumeric paging input terminal from **Ralco Electronics** features automatic dialing, 80-character display, programmable pause behind PBX, dial tone on line detection, function key dialing directory and selectable communications parameter.

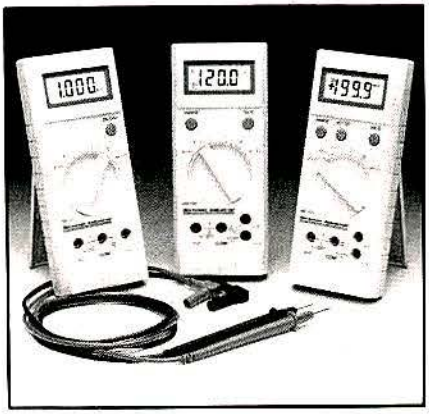
Circle (278) on Fast Fact Card

Spectrum analyzer covers 100Hz to 5GHz range

The FSB spectrum analyzer from **Rohde & Schwarz** covers the 100Hz to 5GHz range with intrinsic noise below −145dBm. Automatic test routines include frequency and bandwidth correction routines, internal self-test, frequency and level marker and level.

Circle (274) on Fast Fact Card

Autoranging multimeters have battery-saver feature



Autoranging multimeters from **Contact East** include audible signaling that uncovers intermittents. Units measure ac and dc volts, current and resistance and feature an auto-off for battery saving. Models come with test leads and battery.

Circle (268) on Fast Fact Card

Lithium batteries fit low-drain requirements

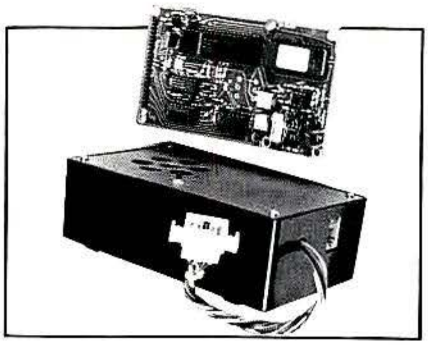
Circle (253) on Fast Fact Card

The MicroLithium series of **Duracell** XL lithium batteries suits low-drain requirements. There are 17 cell sizes available that range from 35mAh to 2,500mAh capacity. Laser-welded PC pin terminations for wave soldering and printed circuit-board mounting are available with most of the cells.

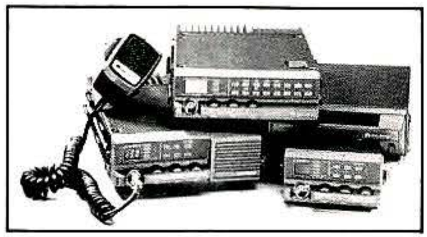
Remote switch permits area, channel monitoring

The RA5 remote area switch from **Parkinson Electronics** connects a conventional dc remote system with a GE trunking system control station. It permits area, group and channel monitoring. No modifications are required to the remote units. The radio function is advanced and announced by a synthesized voice as the remote's monitor button is pressed continuously.

Circle (203) on Fast Fact Card



Lowband mobiles' output adjustable from 25W to 50W



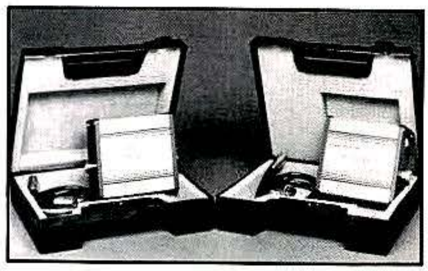
Syn-Tech II lowband mobiles from **Midland LMR** offer an adjustable RF output from 25W to 50W. Maximum frequency spread and transmitter and receiver frequency offset are 6MHz or 8MHz, depending on model. The radios have 320-channel capacity in as many as 16 groups. Features include programmable channel scanning with dual priority, programmable signaling and built-in data ports. The radios are programmable with a dc-powered programming unit via a preloaded data module or cloning from radio to radio. The radios have die-cast chassis and meet military standard 810 C and 810 D.

Circle (221) on Fast Fact Card

Circle (133) on Fast Fact Card

Circle (134) on Fast Fact Card

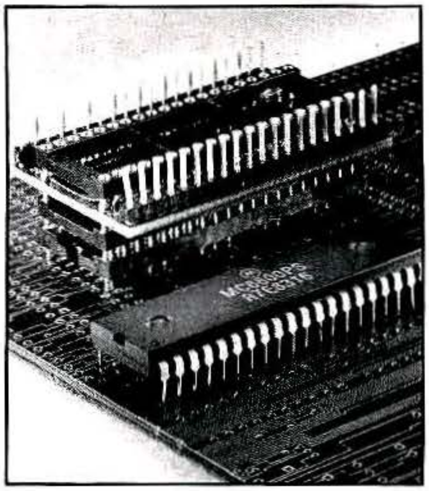
Test set power heads allow concurrent measuring



Two power heads from **Marconi Instruments** for its 2955 radio communications test set allow simultaneous measurement and display of forward and reverse power and VSWR in RF transmission lines and antenna systems. The HF directional power head spans 1MHz to 50MHz and measures power from 10mW to 400W. The UHF unit covers 25MHz to 1GHz and measures power from 10mW to 100W; it can indicate power to 200W for carriers to 200MHz. The units feature dual auto ranges, automatic sensing of forward and reverse power and auto nulling.

Circle (230) on Fast Fact Card

Test adapters fit DIP packages



Test adapters from **Pomona Electronics** provide test points for DIP packages on top of the adapter. Three socket-mounted models are available: Model 5442 for 40-pin, model 5443 for 48-pin and model 5444 for 64-pin DIPs.

Circle (386) on Fast Fact Card

Switch allows expanded trunk capability

The enhanced SS-450E super switch from **Hark Systems** has expanded trunk capability for expansion of input ports from two to 16. It incorporates DID trunk concentration, call forwarding and trunk splitting. Call data accumulation tracks system usage by subscriber for billing purposes and traffic studies.

Circle (267) on Fast Fact Card

Three multiprogrammers are incorporated in unit

The 135-H multiprogrammer from **Bytek** features eight 32-pin ZIF sockets and is three multiprogrammers in one unit: Gang (E)EPROM duplicator, set (E)EPROM programmer and universal programmer. The unit offers four modes of operation: stand-alone programming, computer remote control, terminal mode and optional PROMSoft, IBM PC compatible software for menu-driven operation.

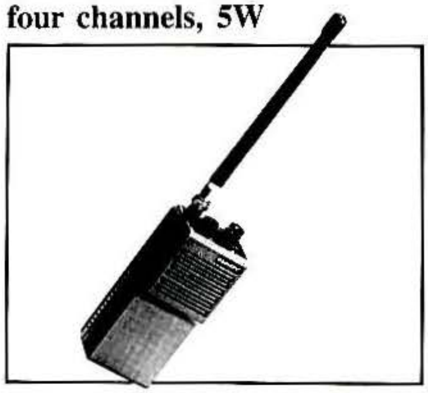
Circle (281) on Fast Fact Card

Battery packs fit Yaesu FTC1123, FTC1143

Battery packs for Yaesu models FTC1123 and FTC1143 radios from **Periphex** feature more capacity than the original batteries. Replacement pack FNB-4SH for the FNB-4 offers double the capacity of the original battery pack at 12V and 1,000mAh with 3.5W output. The FNB-3S, which replaces the FNB-4, offers nearly triple the capacity of the original pack at 9.6V and 1,200mAh. The battery packs feature overcharge, over temperature and short circuit protection.

Circle (322) on Fast Fact Card

Portable offers four channels, 5W



The Easytalk VHF-30 miniature 5W two-way radio from **Nady Systems** has four-channel capability. The transceiver transmits from 5 to 7 miles, even in severe interference environments. The VHF-30 is protected by an impact-resistant case, and its internal microcircuitry is sealed from contaminants by special gaskets. The radio includes a rubber duck antenna with a BNC connector, an ac-dc wall charger, a stainless-steel belt clip, a protective holster-style carrying case and a 10.8V nicad rechargeable battery pack. One standard channel is installed; as many as three extra channels can be added.

Circle (218) on Fast Fact Card

18GHz digital radio offers automatic frequency control

The Ultrastar 18 DLR digital microwave radio from **Motorola** offers industry-standard digital interfaces: DS-2 and 4xDS-1 for U.S. use; CEPT-1, CEPT-2 and 4xCEPT-1 for international use. The radio features automatic frequency control and modular construction. A data tester is standard.

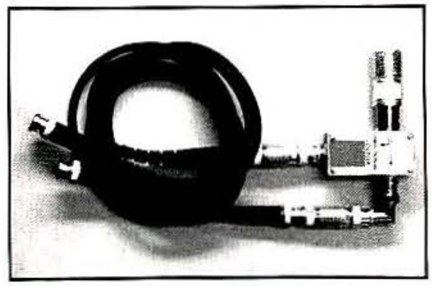
Circle (245) on Fast Fact Card

Remote display unit prints alarm messages

The CSI-14 remote display unit from **Communications Systems** permits automated remote control of the CSI-52 power I/O module controller. It acts as a control center and monitors and controls remotely located CSI-52s via two-way radiolink. The unit can print status and alarm reports. Features include eight-digit alphanumeric display, battery-backed RAM, RS-232 serial printer port and an adjustable DTMF signaling speed.

Circle (254) on Fast Fact Card

Kit displays SWR vs. frequency on CRT



The Swer-Sweep kit from **Tekcom** is used with any spectrum analyzer and tracking generator to display SWR vs. frequency on the CRT display. The kit can be used in tuning antennas, tuning helical RF preselector front ends, tuning filters and duplexers and checking transmission line resonance and SWR at any frequency. The kit includes a 20dB directional coupler with 40dB directivity calibrated from 1MHz to 500MHz; two 6dB calibrated attenuators; 50 calibrated load; two low-loss RF cables with strain reliefs; and an instruction manual and return loss chart.

Circle (228) on Fast Fact Card

Equipment for sale

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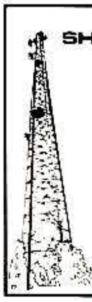

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Tower services

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- STACKING TO 100 FEET
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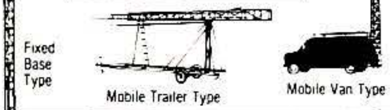

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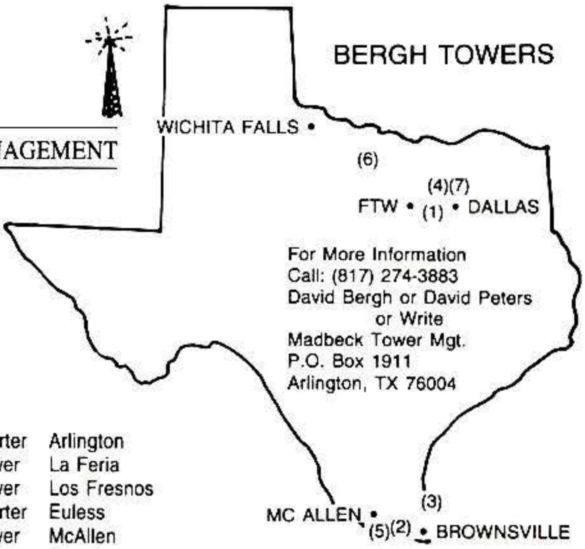

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David Bergh or David Peters
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Ad index/hotline

Company	Page Number	Fast Fact Number	Advertiser Hotline
A.I.E.	110	107	803/532-9256
Advanced Electronic Applications, Inc.	98	90	206/775-7373
Advanced Receiver Research	8	8	203/582-9409
Air Comm	153,155	177,188	602/275-4505
Alexander Batteries	21	18	515/423-8955
Antenna Specialists Co.	IFC	1	216/349-8400
Astron Corp.	91	82	714/458-7277
Auburn Electronic Laboratory	156	190	502/542-6000
B-D Crystal	151	171	306/283-5000
Band-It-Idex	12	10	303/320-4555
Barnett Electronics	153		800/423-3858
Basic Comms	153	180	601/649-2465
BEE Electronics, Inc.	28,42	22,36	800/336-3115
Bendix/King	53	45	913/842-0402
Bomar	137	137	800/526-3935
Bramalea Inc. (First Republic Bk.)	159	211	214/761-6277
BYTEK Corporation	139	139	800/523-1565
C T Systems	13,43	11,37	800/245-6356
Cablewave Systems Inc.	136	153	203/239-3311
Cadex Electronics Inc.	70	61	604/522-8046
California Radio	151		800/231-0103
Cartwright Communications Co.	103	96	800/543-8614
Celwave	77	68	201/462-1880
Centurion International, Inc.	35,57	32,49	800/228-4563
CES, Inc.	7,117	7,116	800/327-9956
Cetec Vega	1	4	818/442-0782
David Clark, Co., Inc.	74	66	617/756-6216
Coded Communications	25	20	800/325-0147
Comark Distributing	154	183	800/777-2708
Commonwealth Communications Industries Ltd.	105	99	800/633-8844
Communications Associates	126,150	128,166	800/435-9313
Communications Specialists	BC	3	800/854-0547
Connect Systems, Inc.	19,144	17,146	213/373-6803
Control Signal Corp.	16	14	303/989-8000
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Microflect	61	53	503/363-9267
Microlink, Inc.	133	155	713/488-6011
Mid-America Distributors, Inc.	120	121	800/888-1654
Midian Electronics, Inc.	56	48	602/884-7981
Midland International LMR	50-51	43, 149-152	800/MID-LAND
Milcom International, Inc.	27	21	714/554-1710
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Modublox & Co., Inc.	96	87	619/456-0016
Multiplier Industries Corp.	128	129	800/642-2424
John Murray Associates	134	136	303/444-4871
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NCE/National Custom Enterprises, Inc.	88	79	612/890-1360
Nokia-Mobira, Inc.	39	34	800/628-2828
Norcomm Corp.	117	115	800/874-8663
Omnicron Electronics	99	92	203/928-0377
Pac-Comm Wireless Data Sys, Inc.	86,112	77,110	813/875-6417
Pace, Inc.	114	113	301/490-9860
Page Com., Inc.	60,135	52,135	800/527-1670
Page Com, Inc.	152	153	214/680-9750
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Securitron Co.	32	28	408/263-6434
Selectone Corp.	15	13	800/227-0376
Setcom Corp.	124	125	415/965-8020
Sharp Communication	153	179	800/548-2484
Shinwa Communications of Am.	62	54	405/232-7272
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TDI Batteries	106	100	800/323-7307
Tec Antenna	100	101	714/962-4134
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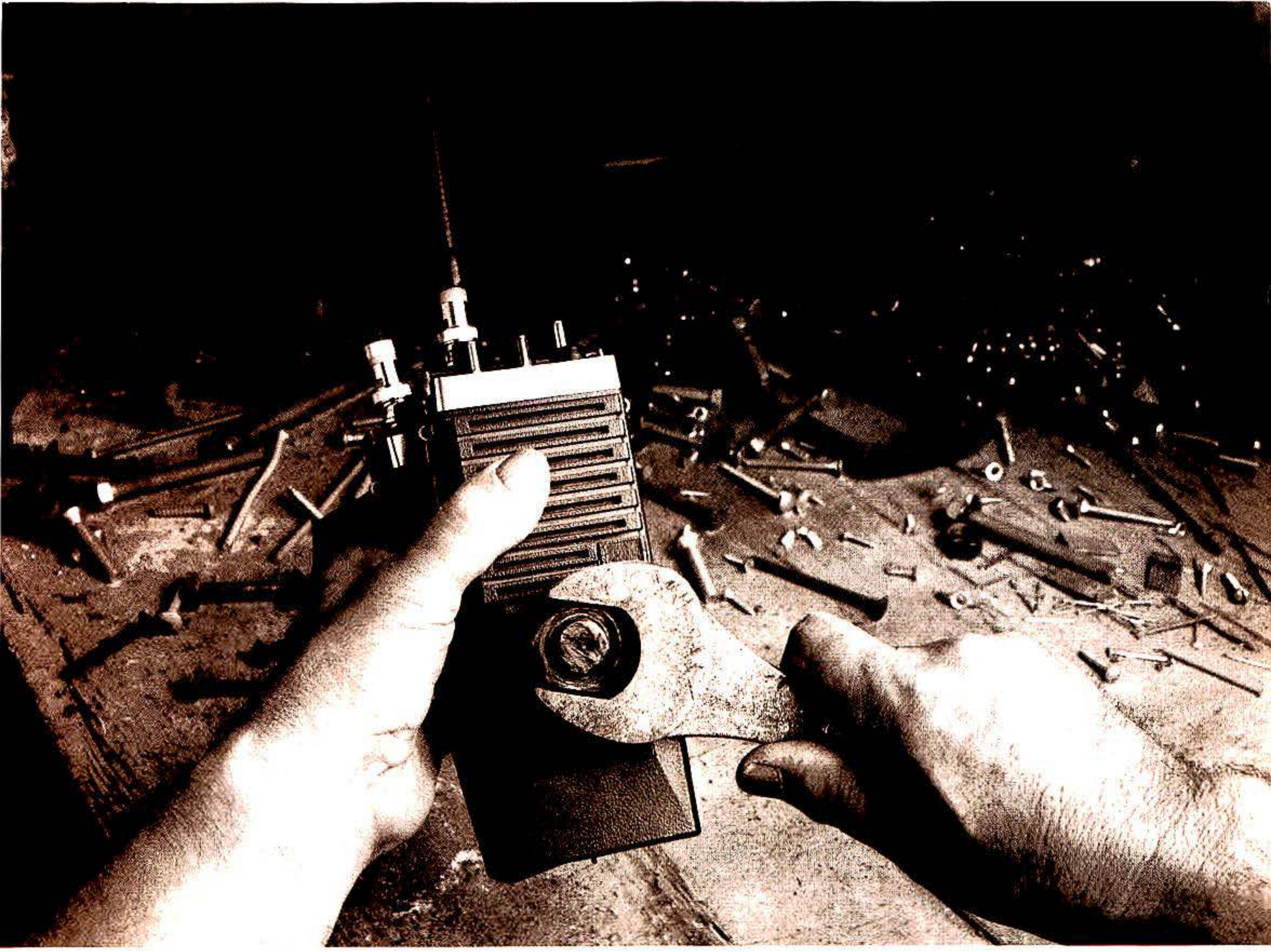
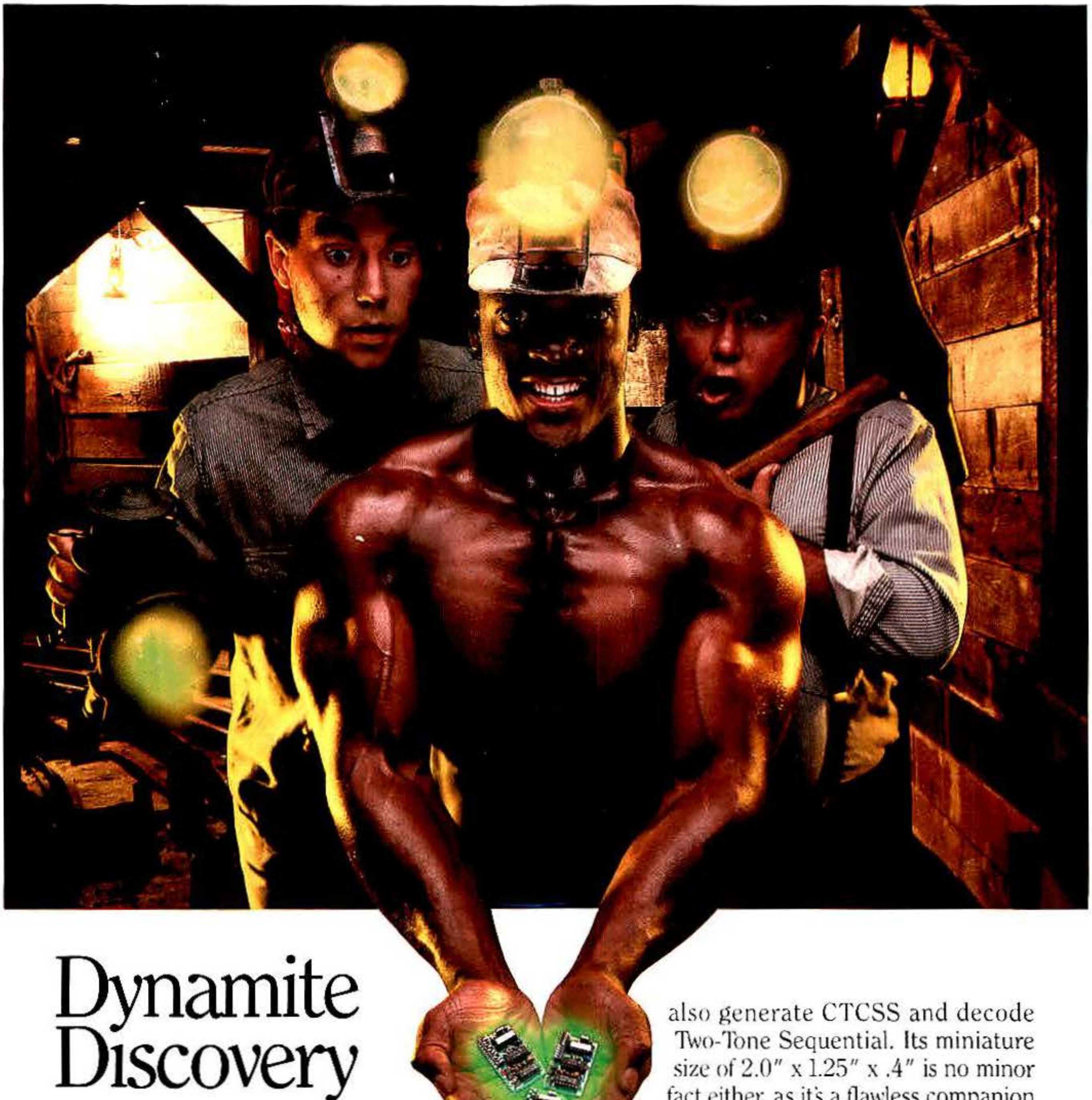
Trident Micro Systems	100	93	714/549-5206
Transcrypt Intl., Inc.	5	6	800/228-0226
Trilectric Div. Celltronics, Inc.	115	114	800/551-8551
Trylon Intl. Inc.	32	29	519/669-5421
TX RX Systems	92	83	716/549-4700
Uniden Corp. of Am.—MSG Inc.	41,89	35,80	800/421-8894
Unipage, Inc.	23	19	214/224-3509
Vidcom Manufacturing	101	95	313/261-9444
Vocom Products Corp.	132	133	312/885-3296
W & W Associates	54	46	800/221-0732
Brian R. White Co., Inc.	108	103	707/462-9795
Yaesu USA	IBC		213/404-2700
Zetron, Inc.	75	67	206/644-1300
ZK Celltest Systems	139	140	408/735-7076





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